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The Recent Floods at Monterrey, N. L., Mexico.

By G. R. G. CONWAY,* M. Am. Soc. C. E., M. I. Mech. E.

(With full-page plate.)

Monterrey has recently passed through a disastrous flood, greater than any previously recorded in its history. This flood is of great engineering interest and a few facts which the writer has hastily gathered may be of service to the readers of Engineering News.

Monterrey is situated chiefly on the north bank of the River Santa Catarina, a tributary of the San Juan River, and ultimately finds its way into the Rio Grande. On the opposite side of the river is the suburb of San Luisito, a thickly populated district chiefly inhabited near the river banks by a large "peon" class. The houses on both sides of the river are of a poor class, many of them merely wooden huts; but a large number built of "sillar," a local rock of sedimentary limestone origin, excellent for building purposes in a dry country but inadequate to form substantial buildings to resist long continuous rains.

The great flood occurred on the night of Aug. 27 last, bringing with it disaster on every side and a loss of life which it is feared may reach the enormous total of 5,000 persons.

The Santa Catarina River above Monterrey is about 56 miles in length, that is to say to the remotest point in the water-shed. The water-shed area above the city of Monterrey is approximately 1,410 square kilometers, or 544 square miles (see Fig. 1). Its length is about 20 miles and its maximum width 28 miles. The greatest elevation of the water-shed is about 2,369 meters (7,820 ft.), while the city of Monterrey lies at an altitude of 535 meters (1,766 ft.) above sea-level. The average annual rainfall at the city of Monterrey for the past 21 years is 19.86 ins.

The great flood of Aug. 27 and 28 was preceded on Aug. 9, 10, and 11 by a flood of considerable magnitude, greater indeed than any which had occurred since the year 1881. This flood followed a period of exceptional drought which is supposed to have been more severe than any drought during the last 30 years. During the year previous to these floods only about 10 ins. of rain had fallen, while in the previous months from January to Aug. 10, only 8 ins. was recorded.

At midnight on Aug. 9, rain began to fall heavily and from that time until 6 p. m. on Aug. 11, 13.38 ins. of rain was recorded in the rain gage at the water-works company's office.

THE AREA SWEPT BY THE FLOOD OF AUG. 28 IN MONTERREY, MEXICO; PHOTOGRAPH TAKEN SEPT. 4.

(In the background may be seen the San Luisito Bridge. The river broke through at the left of this bridge and entirely swept away a thickly populated section.)

This rain fell as follows:

	Inches.
Aug. 9, 12 midnight to noon, Aug. 10	3.50
Aug. 10, 12 noon to 8 a. m., Aug. 11	7.11
Aug. 11, 8 a. m. to 6 p. m., Aug. 11	2.77
Total for 42 hours	13.38

In the first 30 hours, 10.61 ins. fell. The most intense period of rainfall which caused the flood came between 6 p. m. and 11 p. m. on the evening of the 10th, when 5.019 ins. was collected, or an average of 1 in. per hour for five hours.

The flood broke through on the south side of the river near the new San Luisito Bridge, described in Engineering News of April 8 last, and with insufficient floodway this bridge deflected the current southwards to San Luisito, causing considerable damage to property and a loss of about 14 lives.

The river continued to run for a few days, and its bed at Monterrey then dried up completely. It should be remarked that under normal conditions the Santa Catarina River is dry at Monterrey. What water there is flowing in the river above ground is taken out for irrigation purposes 12 miles above Monterrey. It is only on two or three occasions during the year when there is any flow at all in the river at Monterrey.

Hardly had this flood disappeared when the river was subjected to another enormous flow and on the evening of the 27th, about 11 p. m., the river came down in an enormous volume and with great velocity, practically destroying a great part of San Luisito and the low lying districts north of the river.

The following is a record of the rainfall as measured on the gage at the water-works office in the center of the city, this gage is placed on the roof of the office about 20 ft. above the ground, and in consequence the record is a low rather than a high one. The readings were from the period, dating from Wednesday, Aug. 25, from 4 p. m., until Sunday, Aug. 29, at 6 p. m., a period of 98 hours, which gave a total of 21.61 ins., as follows:

Date.	Interval.	Duration.	Amount.	Rate.
Wed. Aug. 25	4 p. m.-6 p. m.	2 hours	2.80 ins.	1.4 ins. per hr.
Thur. " 26	6 p. m. (25th)-8 a. m.	14 "	0.29 "	
Fri. " 27	8 a. m. (26th)-8 a. m.	24 "	0.86 "	
" " 27	8 a. m.-3 p. m.	7 "	0.96 "	
" " 27	3 p. m.-6 p. m.	3 "	0.86 "	
Sat. " 28	6 p. m. (27th)-6 a. m.	12 "	6.85 "	1.50 ins. per hr. for 2 hrs.
" " 28	6 a. m.-9.30 a. m.	3½ "	2.30 "	1.80 ins. per hr. for 45 mins.
" " 28	9.30 a. m.-6 p. m.	8½ "	2.12 "	
Sun. " 29	6 p. m. (28th)-7 a. m.	13 "	3.04 "	
" " 29	7 a. m. (28th)-6 p. m.	11 "	1.53 "	
	Totals	98 hours =	21.61 ins.	

*Chief Engineer, Monterrey Waterworks & Sewer Co., Ltd.

The mean monthly rainfall for August during the last 21 years is 3.544 ins., while for September, which is the wettest month in the year, it is 4.276 ins. The total recorded rainfall for August, 1909, amounts to 34.99 ins.

The greatest flood period occurred on the evening of Aug. 27, when the approaches at the south end of the San Luisito bridge gave way, thus directing the current to the south, sweeping away hundreds of "sillar" houses and completely obliterating many streets on both sides of the river. The bridge itself is a two-span structure of reinforced concrete. It had a flood area of only 1,680 sq. ft., but it stood the torrent and was the means of saving much valuable property to the north of the city, as it acted as a dam and deflected the main scour southwards.

From approximate observations made, the velocity of the current was about 15 miles per hour. From a cross-section of the river the flood section was found to be 12,650 sq. ft., this gives the enormous discharge of 278,000 cu. ft. per second.

This computation of maximum flow the writer believes to be a conservative one, taking into consideration the facts that the floods of Aug. 9, 10 and 11 had completely saturated the limestone strata of the water-shed area, and also the fact that the whole of the region above Monterrey is barren, precipitous and free from vegetation or plant growth of any kind, and that a maximum intensity of the rainfall, viz., 1.50 ins. and 1.80 ins. per hour was attained on Friday night the 27th and in the morning of Saturday the 28th. We can therefore safely assume a discharge of at least 75% of the total rainfall.

At every point along the river the underflow water appeared at the surface and the temporary wells of the water-works company's infiltration gallery rose about 20 ft., or practically to the surface of the river, although at a considerable distance from it. Assuming, then, as a fair average 1 in. of rainfall per hour over the whole water-shed we obtain with a discharge of 75% of the total quantity about 265,000 cu. ft. per second, or an average on both methods of calculation of 271,500 cu. ft. per second—a rate of run-off equal to about 500 cu. ft. per second per square mile of water-shed.

In the adjoining small water-shed of the Estanzuela River which furnishes to Monterrey its high-pressure water-supply, the quantity of water flowing over the dam amounted to 2,900 cu. ft. per second, or 825 cu. ft. per second per square mile. The drainage area above the Estanzuela dam amounts to only 3½ square miles, with a difference in elevation of nearly 5,000 ft. between its highest point and the dam, but most of the water is derived from perennial springs which are fed from the Santa Catarina water-shed. For purposes of comparison Table II. is attached showing the flood run-off of other rivers.

Fig. 4 shows the enormous change that took place on the north bank of the river immediately below the San Luisito bridge, the scour completely demolishing one complete city block and raising the river level in its old channel and making an entirely new one farther north.

Fig. 2 shows the general plan path of the torrent through the city. Within the city limits the area submerged amounted to about 517 acres, and of this total about 452 acres was well built up. All this property was completely destroyed.

The effect of the flood below Monterrey has been most disastrous, but the writer has had no opportunity of studying the conditions above the city.

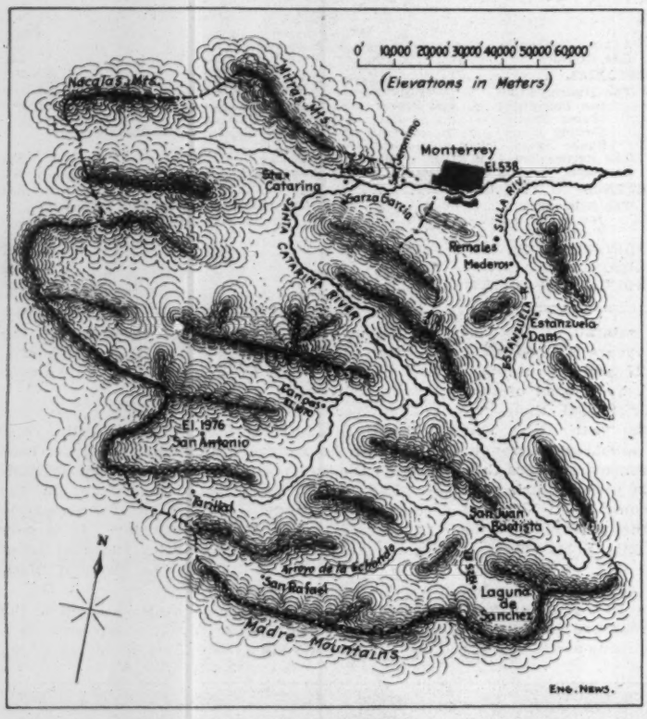


FIG. 1. MAP OF THE WATER SHED OF THE SANTA CATARINA RIVER ABOVE THE CITY OF MONTERREY, MEXICO.
(Total area, 544 sq. miles.)

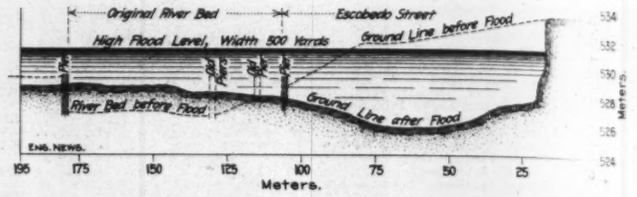


FIG. 4. PARTIAL CROSS-SECTION OF SANTA CATARINA RIVER ON LINE OF ESCOBEDO ST., MONTERREY, BEFORE AND AFTER FLOOD.

TABLE II.

River.	Drainage area in sq. miles.	Maximum recorded flow in cu. ft. per sec.	Cu. ft. per sec. per sq. mile.	Annual amount rainfall in ins.
Santa Catarina, Monterrey, Aug. 27...	544	271,500	500	22
Estanzuela, Monterrey, Aug. 28.....	3½	2,900	825	25
Tansa, India.....	52.5	35,000	666.7	101
Khrishna, India.....	345	118,000	342.6	258
Irawaddy, India.....	149,810	1,900,000	12.7	368.4
Ganges, India.....	367,970	1,800,000	4.9	26.91
Ohio, U.S.A. (Cairo).	214,000	700,000	3.3	54.9
Delaware, Lambertville, N. J.....	6,820	250,000	36.5	45
Colorado, Austin, Tex.	37,000	123,000	3.3	24.5
Sweet Water.....	186	18,150	97	...
Mississippi, St. Louis.	1,226,000	994,000	.8	...
Nile at Assuan.....	1,300,000	459,000	.35	...

NEW YORK CITY STREET RAILWAY TRAVEL exceeds that of all other cities of the world, amounting to 1,323,326,635 passengers last year. This is nearly 18% of the total travel on steam and electric railways in the whole United States.

AN ELEVATED RAILWAY FOR PHILADELPHIA, proposed by the Philadelphia & Suburban Electric Elevated Ry. Co., has the peculiar feature of occupying two parallel streets with two single-track lines, connected at the ends by loops. This arrangement is due to the narrow streets, and follows the example of many street railway lines in Philadelphia. The elevated railway would occupy 12th and 13th Sts., with a southern loop connection on Johnson St. At the junction of Glenwood Ave. and Germantown Ave. the two lines would unite on a double-track structure extending on Germantown Ave. to a terminal loop at Wayne Ave. At Market St. there will be a main station with loops, and this will serve the Philadelphia & Reading Ry. terminal. Mr. S. S. Neff (formerly Superintendent of the Chicago elevated loop and the Boston Elevated Ry.) is President, and Mr. Caspar W. Haines, M. Am. Soc. C. E., is one of the directors.

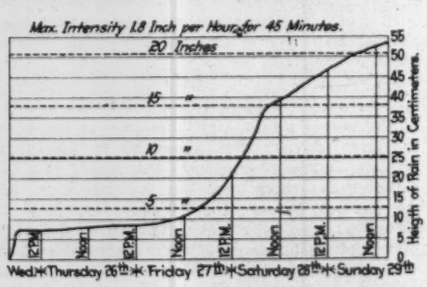

Max. Intensity 1.8 Inch per Hour for 45 Minutes.
20 Inches
15 "
10 "
5 "
Noon
Wed. Thursday 26th Friday 27th Saturday 28th Sunday 29th
Height of Rain in Centimeters.

Fig. 3. Diagram Showing Amount and Intensity of Rainfall at Monterrey During Floods of August, 1909.

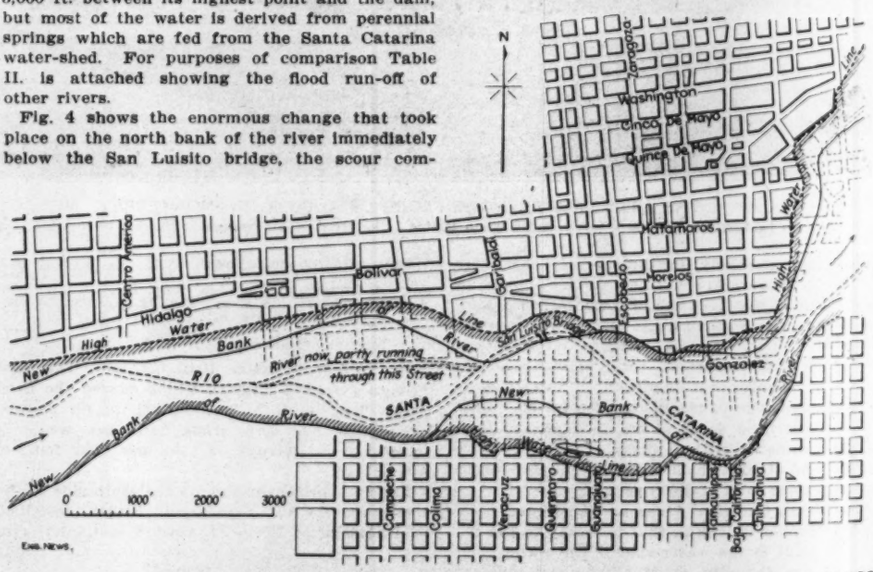


FIG. 2. MAP OF PART OF THE CITY OF MONTERREY, SHOWING AREA SWEPT BY FLOOD OF AUGUST 27 AND 28, 1909.

Unsatisfactory Experience with Petrolithic Pavements at El Paso, Tex., and Los Angeles, Cal.

The so-called petrolithic pavement formed by the incorporation of an asphalt oil with the surface layers of a dirt road has been extensively exploited in the technical press and the publications devoted to road improvement during the past two or three years. In our issue of July 29 we printed a letter sent us by Mr. D. L. Wardroper of Atlanta, Ga., who was engaged in exploiting this pavement in Georgia.

This publication has drawn out some records of actual experience with the petrolithic pavement and we print below a letter received from Mr. J. L. Campbell, of El Paso, Tex., and follow it with reports on the pavement made by the authorities of El Paso and Los Angeles. Comment on the discussion is made on our editorial page.

Sir: I have noted the enthusiastic account of petrolithic pavement, by Mr. Wardroper, on page 127 of your issue of July 29, 1909. The optimism expressed in this information, prepared for prospective road buyers in the State of Georgia, is evidently not dimmed by the fact that the narrator has a financial interest in the matter.

We have in El Paso at this time a like promotion of this pavement, so-called, which is in fact merely an improved oiled road. Similar conditions exist in and about Los Angeles, Cal.

Fig. 1. View Taken July 7, 1909, to Show Effect of Heavy Teaming.

Fig. 2. Effect of Horse Pawing.

Fig. 3. Break of Street Surface in Gutter, from View Taken on July 25, 1909.

I invite your attention to the attached copy of a report of the Inspector of Public Works to the Board of Public Works of the city of Los Angeles, dated July, 1909, in which he says, referring to this class of construction, "Except the real estate promoters and the oiled road contractor it now has no place in our favor."

Mr. Wardroper says, "Whether the material is soil, sand, gravel, worn-out macadam or other granular and stable material, makes little difference as to the final good character of the completed pavement." This is flatly contradicted by Mr. Homer Hamlin, City Engineer of Los Angeles, who says in a letter to me of July 12 (copy herewith), "There is a great difference in the character of results accomplished under this process even on the same street, due apparently to different texture and character of soils."

Mr. Wardroper says that his statements are based on his observations of the study of petrolithic pavements in Southern California and in El Paso, Tex. He refers to a mile of petrolithic construction on Wyoming St. in El Paso. The present surface condition of this street, which has been open for traffic for about sixty days, fully confirms the statement of the city engineer of Los Angeles that, "There is a great difference in the character of results accomplished with this process even on the same street." On a very limited part only of the surface of Wyoming St. has the petrolithic surface come out to anything at all resembling even remotely an asphalt or bitulithic surface. Seventy-five per cent. of the traveled surface of this street is already grinding up into a brown oiled dirt, varying in amount and degree on the various blocks. The promoters of this pavement here say that in the course of time the entire surface will come out to an asphalt appearance. I enclose herewith two photographs of two blocks of this street, taken about 5 o'clock, July 7, 1909, after about sixty heavy freight wagons had passed over the completed pavement, which had then been in service for about thirty days. [We reproduce only one of the views (Fig. 1). The other shows nearly as bad a condition of street surface.—Ed.] These photographs show very plainly that the street surface was, for the time being at least, entirely ruined by one day's heavy traffic over it. This damaged surface has since been rolled out; in fact, was rolled out the following night, and it is now as smooth as other portions of the street and probably will remain so until again subjected to heavy traffic.

Mr. Wardroper says the petrolithic pavement strongly resembles sheet asphalt and bitulithic pavements in their grayish black color and in their smoothness and evenness when the latter pavements are in good condition. It would require a violent, in fact impossible, stretch of the imagination to conceive that this statement even remotely describes the appearance of the petrolithic construction on Wyoming St. at the present time. The photographs mentioned give a very much better idea of its appearance. I also enclose a third photograph (Fig. 2) showing the result of a horse pawing this petrolithic surface, also a fourth photograph showing a break of the surface in a gutter (Fig 3).

The surface of this street was finished by a thin spread of oil, on which about a half-inch of rock screenings, running from the size of small marbles down to fine particles, was spread. In the center of the street where the traffic is now running this stone and oil is, as a rule, grinding up into an oiled dirt and is not rolling out to an asphalt surface. On the untraveled portion of the street surface the latter is still composed of loose stone screenings, incapable of being washed or swept without sweeping away the surface. This condition is diametrically opposed to Mr. Wardroper's statement that, "It is evident that the very nature of the pavement renders it the most perfect from the viewpoint of good sanitation."

From the enclosed reports of the Mayor and City Engineer of El Paso, Tex., and of the City Engineer and Inspector of Public Works of Los Angeles, it is quite evident that a large proportion of the petrolithic roads of Southern California are anything but the perfect pavement described by Mr. Wardroper. The writer has seen the oiled roads of Southern California and from his observation and reliable information none of them have ever proved to be anything but permanent failures under any considerable amount of sustained traffic. The petrolithic process is, of course, an improvement over the original oiled roads of California and undoubtedly it should last longer on account of the greater care and amount of work expended in its construction, but the binding element on which the life of all these oiled roads finally depends is the same in all cases.

The petrolithic form of construction is necessarily a crude and uncertain process, because it takes the natural road material mixed with oil as the binder to hold together the crushed stone or gravel added thereto. It is a crude and uncertain process on account of the great variability of one of the constituents of this binder, i. e., the road soil, as experience has abundantly proved. Therefore, Mr. Wardroper's statement that, "Whether the material is soil, sand, gravel, worn-out macadam or other granular and stable material makes little difference as to the final good character of the completed pavement," will certainly get a lot of people into serious trouble if they accept such a statement without qualification or investigation and act upon it accordingly.

In the construction of Wyoming St. in El Paso, the crushed rock which was added to the construction was first thoroughly mixed with the soil by cultivators and was afterwards still further embedded in the soil by the rolling tampers so that when the work was completed ready for the finishing coat of oil and fine stone the crushed rock previously added did not appear upon the surface. It was entirely buried in the body of the pavement and the surface of the latter prior to the application of the finishing coat was nothing but oiled dirt about an inch thick. Wherever the street, finished to that extent, was opened to travel prior to the application of the finishing coat, the surface promptly ground up into a loose oiled dirt over a large proportion of the street surface. Only in cases where an excess of oil was used was this disintegration into oiled dirt prevented. The finishing coat, including oil and fine stone, is about ½-in. thick, and as soon as it is ground up and blown away the traffic will then be down on to the oiled dirt underneath, and the indications are that the street will become highly objectionable to adjacent residents. Possibly this surface may come out to the asphalt surface predicted by its promoters and constructors and be as good as some of the best of the successes with this form of construction in some of the suburbs of Los Angeles, but the present indications do not justify such an expectation.

The attached correspondence shows that I have had occasion to investigate somewhat particularly the history of petrolithic construction to date, as a result of which I am opposed to its use on Rio Grande St., in El Paso, notwithstanding that it costs very much less than bitulithic or standard asphalt.

In his letter of July 12, attached, the City Engineer of Los Angeles says, referring to petrolithic, "It is not a pavement in any sense and is not satisfactory where a pavement is needed." Again he says, "Dry oil and dust accumulate on the surface in summer and it becomes muddy in the winter." He further says, "We use this class of improvement only on residence streets and are recommending a better improvement than petrolithic even for such streets."

Referring again to the attached report of the Inspector of Public Works of Los Angeles, you will note that he handles the matter without gloves and incidentally throws a little light on the political aspects of the case, which apply admirably to present conditions in El Paso. In this connection he says, "These people are strong and influential. They present their case in the most plausible manner." The petrolithic construction in El Paso is being done by a home company of strong and influential persons very close to the City Council. In fact, at least one of the councilmen has a relative who has a considerable interest in this home company. I do not mean to infer that any improper consideration has influenced the action of the council or any member of it, because our city council as a whole and individually is, like Caesar's wife, "above suspicion." The existing state of affairs, however, is not antagonistic to a natural and perhaps unconscious tendency to accept a home product when backed by influential personal and political friends on grounds in which the merits of the product are not altogether a controlling factor.

As the background for this communication I submit herewith for publication, if you desire, all or any part of the report of the Mayor and City Engineer of El Paso, my letters to the City Council of El Paso, my correspondence with the City Engineer of Los Angeles and the report of this engineer and also the report of the Inspector of Public Works of Los Angeles.

Yours truly,

J. L. Campbell,

[Chief Engineer, Maintenance of Way, El Paso & Southern System.—Ed.]

El Paso, Tex., Aug. 5, 1909.

Report of the Mayor and City Engineer of El Paso.

(We reprinted these reports from the El Paso "Herald," which prefaces them by stating that the Mayor and City Engineer went to California to inspect the paving at the expense of the Petrolithic Co.)

The Honorable Mayor Pro Tem. and Gentlemen of the City Council of the City of El Paso, Texas:

Gentlemen: We, the undersigned, herewith respectfully submit this, our report, tending to show the results of our investigations of the Petrolithic pavements in the city of Los Angeles and its immediate vicinity and suburbs.

This committee arrived in this city on Friday, the 25th ult., and have devoted each and every day to date in the inspection of the aforesaid pavements. It is the observation and opinion of the undersigned that a considerable part of the people visiting California and seeing what is termed "oiled roads," often without prejudice or malice whatsoever, come to the conclusion that said oiled roads are Petrolithic. Others, who have better information, voluntarily misrepresent the facts by reason of prejudice or some other motive.

We have found a great many oiled roads in this vicinity. The oiled roads simply consist of a superficial surfacing of oil upon the road, which has a tendency to keep down the dust and obviate the necessity of frequent sprinkling, but the treatment of roads in this way is not calculated to be permanent to any considerable extent by reason of the fact that there is not sufficient quality in the surfacing to hold the road together under any considerable amount of traffic, and the road therefore necessitates constant repairing and attention.

These roads are often covered with an oily dust averaging from a quarter to one inch in depth, and are unquestionably disagreeable for pedestrians or even for pleasure riding. Upon the other hand, we found the Petrolithic streets to be in different degrees of conditions. Where the proper natural conditions existed with reference to soil, and the street was properly worked and a good quality of oil was used in construction of same, almost invariably resulted in a perfect pavement.

We found that the older streets in the vicinity constructed of Petrolithic were constructed without the incorporation of crushed rock, and in several places these pavements have been in use under ordinarily heavy traffic for a period of four years, and at this time are in fairly good traveling condition.

In other vicinities where the natural formation of the soil bears from 15 to 25% of rock or gravel, the pavement is much superior to the one above mentioned, and it was our observation in one particular locality that had approximately eighteen or twenty miles of Petrolithic pavements, this pavement having about 25% of rock in the soil, that the streets after being in use for a period of four years and being located in a hilly section of the country where the rainfall will average 36 ins., all drainage being surface drainage over the streets, these streets were in remarkably fine condition, and we have no hesitancy in stating that the surface of these streets and the general body thereof appeared to equal if not be superior to a great majority of more expensive and costly pavements in the city of Los Angeles.

It is therefore the opinion of this committee that the Petrolithic pavement is suitable for the residence streets; that it is comparatively free from dust providing it has a sufficient amount of traffic over same. Under ordinary traffic it will maintain a smooth and even surface. From hearsay and observation we should judge that the life of the pavement under ordinary conditions without the incorporation of crushed rock in its composition, will last from four to six years.

It is practicable to clean this pavement by sweeping or washing same, and in the event of opening the pavement for the installation of pipes or wires in the base of the street, the pavement can be satisfactorily repaired, providing the proper officials exercise their judgment in requiring the public service corporations to restore the street to its original condition.

In the event of wear on any portion of the street, it is easily susceptible to repair by the proper application of oil and gravel or crushed rock on the worn parts being applied in proper proportion.

Your committee also desire to state that very little attention is devoted to the maintenance and repair of paved streets of all kinds in this vicinity after they have once been put down, and the greater portion of the Petrolithic pavement examined has almost without exception never received any attention or repairs since the day it was laid.

The following will give a general idea of the extent of the investigation and conditions surrounding the various pavements examined by this committee:

The Los Angeles-Pasadena Boulevard, Pasadena, South Pasadena, Glendale, Monrovia, Long Beach, Ventura, Santa Monica and Alhambra, and in each of these places the condition of the different streets has been examined and such information secured as would enable us to find out why some portions were better than others.

Some of these streets are not in good condition, but in all cases where a good grade of oil had been used and sufficient care taken in putting it down, the road to-day has the same appearance of a good asphalt pavement.

There are few of these streets which have been built under the late specifications. Those in Ventura, however, are built practically in accordance with the method now in use in El Paso, and Thompson Boulevard in that city has a very heavy traffic, and we are told that the loads of beans carried over this road are as much as eight tons on a single wagon, or two tons to the wheel, not exceeding five-inch tire, a concentrated load of about 800 lbs. per lin. ft. of tire.

It is also noticeable that the right-hand side of the road leading into Ventura was in better condition than the left-hand side. This is attributed to the fact that the heavily loaded wagons going into town pass over the right-hand side, notwithstanding the fact that this road was constructed of very heavy clay, which does not usually give the best results.

The Los Angeles-Pasadena Boulevard is another street which carries a very heavy traffic, and about three miles of this is of Petrolithic construction. We noticed teams loaded with pipe going over this road, and although these loads weigh at least six tons, the wheels made but slight impression upon the surface.

In the construction of this road a number of different qualities of oil were used, and at this time the condition of the road depends entirely upon the quality of the oil used at any particular place.

Monrovia has a population of about 4,000 and 25 miles of pavement constructed by the Petrolithic process. Four years ago the first road was put down, and after that it became difficult to rent property not on a paved street, which perhaps accounts for so much pavement in a small city. We found the people there particularly enthusiastic on the subject of streets of this kind. The soil carries from 20 to 25% of rock, making an ideal material for road building. The older specifications simply required three inches in depth of plowing and oiling, and the oldest streets had an oil which carried about 50% of asphalt. The latest specifications require an oil of 70% asphalt, and the oiling is done to a depth of 4 or 5 ins. The general condition of these streets is good.

In conclusion we desire to state that the people residing in this section of the country where Petrolithic pavement is in use, are enthusiastic over the pavement. We believe that this is a proper pavement for residence streets in the city of El Paso, and we would heartily recommend that this paving be given a fair and impartial trial, and it is our honest and candid judgment that if such is done it will prove equally successful in El Paso, and will be a paving that will return more in use than the cost thereof.

We will return to El Paso at an early date, and any further information that you may desire in reference to any details not herein mentioned will be given by us with pleasure.

Respectfully submitted,

Jos. U. Sweeney, Mayor.
F. H. Todd, City Engineer.

Los Angeles, Cal., July 1, 1909.

Report of Homer Hamlin, M. Am. Soc. C. E., City Engineer of Los Angeles.

To the Honorable Board of Public Works of Los Angeles.

Gentlemen:

I desire to call the attention of your honorable body to the various methods now in vogue for the improvement of residence streets and to suggest changes which seem, to this department, to be for the better. It is thought best at this point to outline the past progress of street improvement in Los Angeles.

The city is at present maintaining about 514 miles of improved streets of which 64.5 miles are paved, 280 miles are graveled and 169.5 miles are graveled and oiled or otherwise treated with oil. In general, satisfactory cement curbs and walks have been laid on these streets, and this discussion will relate principally to the improvement of the roadway.

The importance of well-paved and well-cleaned streets in the business section of the city is recognized by all, but unfortunately many property owners fail to appreciate the equal importance of properly-improved and well-cared for residence streets. Good streets are essential for the highest development of transportation, drainage and sanitation, not to mention the aesthetic side of our city life.

The city has now reached a stage in its development where more attention must be given to the roadways of its residence streets.

Years ago, when the city was small and traffic light, the old graveled streets are generally conceded to have been fairly satisfactory; at least they were an improvement over the ordinary dirt roads. However, as the time passed and population and traffic increased, these streets began to wear out rapidly and in many cases would have failed altogether had not the city spent large sums in maintaining the same. Some of these streets were graveled no less than twenty-five years ago, and it is little wonder that they have now reached a state of utter dilapidation. Many of our graveled streets would be a disgrace to a country village, and their condition is not improving as time passes. In addition to such expense, the fact must be recognized that suitable gravel is now difficult to obtain, due principally to the great extensions of street work.

In order to cheapen the cost of street improvement for the abutting property owners, principally real-estate promoters, the city council on Sept. 19, [illegible] authorized the use of so-called "natural gravel" [illegible] "natural soil" of the street. This was before the [illegible] of oiled streets. It is, indeed, to be regretted th[illegible]s backward step was taken. The streets improv[illegible]der this plan were simply graded up, nearly every[illegible] in sight being "natural gravel," and the expense of [illegible]staining these psuedo-improved streets was permane[illegible]fastened upon the city. The present condition of [illegible] of the more recent of these "natural soil" street[illegible]fully as bad as that of the older graveled streets. [illegible]e is but one logical position to take in this matter, [illegible] that is to consider these streets as unimproved, so [illegible] as the roadways are concerned.

About January, 1903, the practice of surface [illegible]oiling the streets began in Los Angeles. It was th[illegible] believed by many that the one needful road material [illegible]d at last been discovered. The efficiency of surface [illegible]oil as a dust palliative and for binding a thin coat [illegible] soil on the surface of light-traffic streets is unquestionable; but who can point out a surface-oiled street, graveled or natural soil, in this city, which has remained in good condition after a few months of heavy traffic? It should be evident to any one that merely oiling the surface of a roadway will not make it capable of carrying heavy traffic; there must be a foundation and something to sustain the load and take the wear. The present condition of many of our surface-oiled streets is fully as unsatisfactory as that of the old graveled or natural soil streets which were not oiled, and this after only a very few years' use. The combination of a "surface-oiled-natural-soil" street is most unsatisfactory. The surface-oiled streets wear into ruts, develop waves and lumps and cut up into a particularly exasperating variety of chuck-holes. It seems to be impossible to repair surface-oiled streets in a satisfactory manner at a reasonable cost, and the consequence is that they have not been repaired.

About April, 1907, the Petrolithic process of street improvement came into use in this city. When soil conditions, surroundings and grades are favorable, this process is unquestionably somewhat of an improvement over surface oiling.

Several streets in the city were improved by this process under specifications suggested and approved by the promoters. The work was thoroughly and carefully done and fully up to specifications, or better, but some of these streets have failed completely. It is instructive to inquire into the probable cause of these failures, for it is by such investigations that we better methods and make real progress.

When first exploited, this process consisted of simply mixing the natural soil of the street with heavy oil by various methods and finally tamping the top 4 ins. solid with a special patented roller called a rolling tamper. It soon developed that different soil conditions have a very important bearing on the character of the roadway produced. In general, it may be assumed that a gravely soil with a proper proportion of fine sand and clay to act as a binder will make the best road. If soils are not properly graded from coarse to fine, there is a probability that the roadway will not be stable, but will roll and wear into ruts and chuck-holes. There is also a very great difference in the capacity of different soils to absorb oil, and hence it is practically impossible to get just the right amount of oil on the street. If too little is used, the street will be dusty; if too much, it will be soft and mushy. Moreover, some streets require more oil in certain spots than is called for in the specifications, and less in others. No one can know this or make any allowance therefor before the oil is on the ground and then it is too late to remedy the matter entirely. Further, the amount of water in the soil makes a great difference in the final result, especially if a street is flooded during construction. In such cases, the surface will not harden for a long time, and may cut up into ruts before it does.

Streets improved in this manner are almost invariably dusty during the dry season and work up into mud during rains, especially when shaded by trees along the curbs. The tendency to become muddy is rather more marked on streets where the grade is flat, but some steep streets have also softened up. In general, the results of this method of street improvement have been disappointing.

Later, the promoters of the Petrolithic proce[illegible] urged the necessity of adding 2 ins. of broken stone or gravel to the natural soil of the street. Specifications were prepared by the engineer's department and several streets have been improved in this manner. It was soon found that the rolling tamper tended to bury the stone so deep below the surface of the street that it is of little practical value. The streets improved in this way are also dusty in dry and muddy in wet weather, the addition of the stone making little difference in this respect.

Very recently the engineer's department proposed, and the city council approved, a radically different specification for this class of work. Briefly, it is proposed to oil and tamp the roadway sub-grade with a rolling tamper substantially as formerly, then smooth it off and add 3 ins. of broken stone which will be thoroughly

rolled with a heavy steam roller and then oiled and sanded. This roadway will be, in fact, a thin oiled macadam on a thoroughly competent base. It is believed that this form of construction is a distant advance, and that it will be suitable for use on unimportant residence streets where the traffic is, and always will be, very light.

For the last two years the engineer's department has been using the surfacing of streets with oiled macadam. This class of construction is in no sense an experiment, but has been thoroughly tested in neighboring cities, viz., Pasadena, Redlands and Riverside, as well as in others. It is desired at this point to call attention to the fact that oiled macadam is not a street pavement in the strict sense of the term, nor will it be suitable for heavy traffic streets. It should be used solely on residence streets or where the traffic will be moderate.

This class of road surface is constructed precisely as an ordinary macadam, rolled with a heavy steam roller to a solid unyielding condition, then oiled with a very heavy road oil, sanded or covered with stone screenings, and finally rolled again. When properly constructed, the casual observer will probably not note any difference between this surface and one of asphalt. The surface is, however, more elastic and the sharp click of the horse's feet is deadened far more completely than on an asphalt surface. It is, in fact, one of the most noiseless of street pavements. The oiled surface prevents washing or gullying by running water, sheds the water off the street surface like a roof, and thoroughly binds the surface material in place. These are important features, especially the last, as it will prevent the destruction of the surface by rapidly-moving automobiles. The problem of maintaining the surface of macadam streets and roads under present conditions of automobile travel is one of the most serious problems which road engineers, in general, have to face. We are, indeed, fortunate in having available so cheap and thoroughly effective a binder as the crude asphaltic oils of California.

The cost of oiled macadam is not great; in fact, it is so reasonable in cost that it can be used on almost any residence street, certainly on the more important ones. Bids received, to date, by the Board of Public Works, indicate that it will cost about 10 cts. per sq. ft., laid. This is, of course, exclusive of curbs, gutters and sidewalks, which will be required in any event, where not already constructed. For purposes of comparison, the average costs of other methods of street surfacing now in use are here given:

	Cts. per sq. ft.
Gravel, surface oiled	4
Petrolithic, with natural soil	3
Petrolithic, with 2 ins. of gravel tamped in	4.5
Petrolithic, with 3-in. macadam surface (estimated)	6
Oiled macadam	10

The question now naturally arises: Is oiled macadam worth what it costs? This is answered by inquiring into the known durability and utility of such pavements where they have been in use for a term of years.

In Riverside, Brocton Ave. was macadamized with a soft limestone about twelve years ago, without oil. It began to wear rapidly and became very dusty. To prevent further wear and the ultimate destruction of the pavement, it was afterward thoroughly oiled, and is at the present time in a very satisfactory condition, having cost but little for repairs in all these years. The dust problem was also practically solved by the oiling. In addition, Riverside has several miles of oiled macadam pavements, all of which are satisfactory.

Redlands began the construction of oiled-macadam streets in 1906, using crushed-granite boulders. Several miles of streets have been improved in this manner. These streets have been very satisfactory and have likewise cost but little for repairs.

Pasadena began the construction of oiled macadam streets at about the same time as Redlands, using crushed granite boulders, also. Here, as at other localities, this class of pavement has been entirely satisfactory and has cost practically nothing for repairs.

In Hollywood, one important thoroughfare was paved with oiled macadam in the summer of 1908, using the crushed basalt from the quarry in the Cabuenga Hills, a very superior rock for this purpose. This street was well done and should last for many years.

The probable average life of an ordinary macadam pavement, using good rock, is about ten years. Much, however, depends on the traffic. One ordinary macadam street in the residence district of Los Angeles has been down twelve years and is still a good street. Such pavements usually fail by wearing thin, that is, by gradually grinding up into dust under the wheels, which washes or is blown away; or by the displacement of the individual stones in the surface designated as "raveling out." Ordinary macadam is especially prone to "ravel out" in an arid climate like this. In fact, the only way in which it can be maintained in good condition is by heavy and continuous sprinkling in the dry season, which dampens the fine stone dust due to wear, thereby promoting the cementing or binding of the surface into a close impervious cover. An ordinary macadam must be kept damp to be satisfactory and durable.

Here in the West, however, methods of construction have been changed since crude asphaltic oils became available for road purposes. The surface of an oiled macadam cushions to a very noticeable extent, the impact of horses' feet and the grinding action of wheels thereby greatly reducing the amount of wear on the stone in the road surface. Fully as important as the last, is the fact that the oiled surface binds down and prevents the blowing or washing away of the small amount of rock dust which is produced by wear. This dust is mixed with the oiled surface and materially adds to its further resistance to wear. It is well known that asphalt, sand, and a large proportion of fine stone dust makes the most stable and durable asphalt wearing surface on regularly paved streets. It is believed that oiling macadam will add several years to its life and will make it the most economical of pavements, for streets of moderate traffic.

There are many miles of old worn-out graveled streets within a radius of two miles of the center of the city. Some of these streets, especially those leading into the suburbs, should be paved with asphalt or brick, but the balance should be resurfaced with a cheaper pavement and oiled macadam will be entirely satisfactory for years. It is unreasonable to expect graveled streets 10, 15, 20, or even 25 years old, to be in good condition. The surprising thing about some of them is that they are as good as they are. Moreover, residence property which has not been taxed for 15 or 20 years can and should pay the cost of an oiled-macadam roadway. Property has increased in value to such an extent that the assessment for oiled macadam now will not be as burdensome as was the assessment for gravel several years ago. Our old graveled and natural soil streets must be resurfaced, and very soon. As an example of what should be done, reference is made to Orange St., between Figueroa St. and Alvarado St., where public-spirited residents have requested this class of construction and where work is now under way.

It is proposed by the engineer's department, if your honorable body and the honorable city council concur, to specify oiled macadam for all important residence streets whether improved for the first time or resurfaced; to specify the Petrolithic process with 3 ins. of crushed stone surface for less important streets; and the Petrolithic process with 2 ins. of stone tamped into the natural soil for localities distant from the center of the city and where property is cheap.

It is also proposed to absolutely abandon all other classes of construction, known to have failed in the past, as "natural soil" streets and straight Petrolithic process.

Your earnest cooperation is requested in this important matter in order that we may make rapid progress in the reconstruction and betterment of our streets. Reconstruction is inevitable, but with your assistance and hearty support, it can be brought about much more quickly.

(Signed) Homer Hamlin,
City Engineer.

Los Angeles, March 10, 1909.

Report of W. M. Humphreys, Inspector of Public Works.

Honorable Board of Public Works, City of Los Angeles, Gentlemen:

I desire to present for your consideration the matter of initial street improvement with the hope that the Board of Public Works and the honorable City Council may arrive at some definite fixed policy looking to better streets than now prevail. Of the 514 miles of streets now being maintained by the city 280 miles are graveled, and 169.5 are for the most part natural soil oiled streets. Of the 280 miles of graveled streets many of them, with a reasonable amount of care, will be in service for years to come, but one by one they are going out of commission and becoming an excessive burden to the city and will remain so until rebuilt.

Had we a record of the cost of maintenance of every street, which we are now prepared to keep, we would find that some streets are requiring a greater amount of repairs than should be equitably allowed to same, and this information would furnish some evidence as a cause for the reconstruction of such streets. The question is, under what specifications shall these streets be reconstructed? Of the 169.5 miles of "natural-soil" oiled streets I wish particularly to speak. At the time this class of construction was inaugurated it was unanimously believed by all familiar with the subject that the ideal material for resident road construction had been found. It has taken only a few years to prove the fallacy of this assumption. Excepting the real-estate promoters and the oiled-road contractor, it now has no place in our favor. Consider specification No. 60 under which this work was permitted; it requires three applications of 70% asphalt oil, each application 1 gal. per sq. yd., the first two applications cultivated into the soil 4 ins. deep, the last 6 ins. then tamped with a roller tamper. Now 3 gals. per sq. yd., with oil at $1.10 per bbl., means, on a 40-ft. roadway, that the owner of every 50-ft. lot has incorporated $8.35 worth of assumed material into his street. Results: If 3 gals. per sq. yd. happens to be just the right amount for this particular soil (and there is a considerable difference in the amount of oil required by one kind of soil as compared to another) then we will get a road which *if not used* will stand beautifully for several years. Ample time is thus afforded our hustling real-estate subdividers to unload before destruction takes place; but the purchaser, who believes he had acquired a piece of property the streets of which are to be perpetually maintained by the city, has a subsequent awakening.

There are a few locations where it would seem that Specification 60 might be justifiable, but in 95% of the cases, No. 60 is inadequate for a fair amount of traffic, and does not give a reasonable return on the investment, not to mention the matter of maintenance. Such roads are not only subject to, but are easily susceptible to, every ailment known to bad roads; they are nothing more than good strong bluffs.

This matter has become acute at this time for the following reasons: On the outer limits of our city, in every direction, particularly to the south, there are miles of this class of construction, now in various stages of decay. A few of them have been sprinkled, many have received the annual spring clean-up, but so far as maintenance or repairs nothing has been done except on a few of the most important streets. These people are clamoring for relief. They claim the work has been done under specifications adopted by the city, and of course being owners of property and taxpayers, that they are not receiving the fair proportion of maintenance due them. If it is the desire of the city council to maintain these streets, the street department of course stands ready to undertake the work, but it means an enormous additional burden not heretofore contemplated or provided for.

The other side of this question is presented by the real estate subdivider. At this time we have several applicants before us asking permission to do work under Specifications 60 or 61. No. 61 requires an addition of 2 ins. of gravel to Specification 60. These people are strong and influential, they present their case in the most plausible manner. Permit me to quote the language of a representative of one company which has just finished floating a very successful subdivision, and now desires to make an addition to same. His claim is that they have purchased a large tract of agricultural land, paying as high as $3,400 an acre for part of same, that they have started several houses on this tract, that the work which they will do will open up this farm country, increase the assessable value of property, and provide homes for people who could not stand the burden of high-grade street improvements; that Specification 60 or 61 is ample for the location as testified by streets of the same construction, in the same location, now in good repair after nearly three years' service, and that they are doing business on such a close margin that a higher grade of improvements would compel them to abandon the enterprise.

Our engineer, Mr. Hamlin, has prepared an estimate of the cost of the various classes of construction applied to the former subdivision of the aforesaid company and also to their proposed extension. It is highly instructive, covering the cost of curbs, gutters, crosswalks, sidewalks, grading, etc. From it, we figure that their proposed extension of 32,005.6 front ft. would cost $83 for every 50-ft. lot under specifications No. 60, and $103 per 50-ft. lot under specifications No. 79, the difference in the cost being in roadway improvement. No. 79 requires an addition of 3 ins. of broken stone, rolled, to Specifications 60, and is infinitely better than No. 60. From this point No. 79 we would increase the amount of broken stone according to the importance of the location, up to a point where the cost too nearly approaches the cost of an asphalt surface, which would probably be 6 to 8 ins.

Within the past few years I have visited many of our largest eastern cities, studying park and boulevard system. I do not recall a single instance where I found such poor streets in the residence districts as now exist in our city. I confess I swell with pride when showing my friends our recently-constructed asphalt streets, but otherwise I have little else than apologies to offer. I believe I can say that the average condition of the resident streets of Pasadena is better than we have here at home.

I am informed by Mr. Hamlin that 8-in. macadam streets are quite general through the resident districts of Sacramento and that there are 200 miles of macadam streets in Oakland. The cheapest specifications which we believe should be allowed is No. 81, which requires 1½ gals. of oil per sq. yd. and 6 ins. of gravel, rolled.

We are no longer a prehistoric relic, but a progressive modern city, and the boldness with which we are striking out in some directions only emphasizes the lethargy displayed in this, one of the most important of civic matters.

We are shouting out attractions from the mountain tops, and yet we are ashamed when the tourist travels many of our resident streets.

The matter is in our hands to do, and by doing well we can only hope to receive the commendation of those

we serve. I desire to call your attention to the enclosed most excellent report of our city engineer, on this subject [printed above.—Ed.]

In conclusion, I respectfully recommend that the suggestion of the City Engineer be adopted, to wit: That oiled macadam be specified (Specification 63) for all important residence streets, and either the Petrolithic process with 3 ins. of broken rock, added on the surface (Specification 79) or gravel surfaced oiled (Specifications 81) for less important residence streets within all that portion of the city lying north of the line of Manchester Ave.

Respectfully submitted,

(Signed) W. M. Humphreys,
Inspector of Public Works.

Los Angeles, Cal., July 19, 1909.

Gagings of Small and Large Pipe on the Los Angeles Aqueduct System.

By J. B. LIPPINCOTT,* M. Am. Soc. C. E.

The greater portion of the Los Angeles aqueduct is located in a desert region, requiring in the aggregate the laying of 133 miles of from 3-in. to 6-in. mains for domestic and construction purposes. For designing these lines it was important to obtain a suitable coefficient for determining capacity. The difference between the theoretical computations based upon various formulas, as well as actual observations of discharge in other lines, made it of interest to test the capacities of two of these lines which were of uniform size throughout and without intermediate branch lines or other diversions. These determinations may be of value to other engineers and students and are therefore presented for publication.

Conclusive data are also lacking as to the capacities of large riveted steel pipes after they have been in service for a term of years. For this reason the measurement of the capacity of the 52-in. steel main in the Los Angeles City system will be of special interest.

Discharge of 3-in. and 4-in. Pipe.

KINGS CANYON PIPE, LOS ANGELES COUNTY.—This pipe is 4¼ ins. O. D. casing, having an inside diameter of 4 ins. The length of the line is 12,188 ft. The total head consumed is 358.29 ft. No deduction was made for entry and velocity heads, which would amount to only about 0.57 ft. and therefore would not affect the result appreciably. The flow was measured by a rectangular weir with two end contractions, and computed by the Francis formula.

The discharge was 0.432 cu. ft. per sec. (193.98 gals. per min.). From this the mean velocity in the pipe was computed, giving 4.953 ft. per sec. The resulting value of c in the formula $v = c\sqrt{rs}$ was

$$c = 100.064.$$

This pipe line had been in service about one year. The observations were made by Mr. H. V. Clotts, Construction Superintendent.

NINE-MILE CANYON PIPE, KERN COUNTY.—This pipe is steel casing 3¼ ins. inside, and is 14,203 ft. long. Deducting entry and velocity heads amounting to about 0.87 ft., the head consumed in grade was 821.91 ft. By volumetric measurement the discharge was found to be 0.349 cu. ft. per sec., so that the mean velocity of the water in the pipe was 6.06 ft. per sec. The hydraulic slope being 0.0578, the value of c in the formula $v = c\sqrt{rs}$ was

$$c = 96.8.$$

At the time of the measurements the water was quite brown with iron rust and rather muddy, so that the value of c was expected to be somewhat less than for clean iron pipe. This pipe line had been in service about six months; observations made by Mr. E. A. Bayley, Assistant Engineer.

In both the above cases, the head was measured by a line of levels, carefully run and checked, between the surface of the water in the collecting tank at the intake to the center of the pipe at the outlet.

Discharge of 52-in. Riveted Steel Pipe Five Years Old.

An inverted siphon in the main supply conduit of the Los Angeles city water-works consists of 52-in. riveted sheet-steel pipe. This pipe was laid and put in service in the spring of 1904 and has been in continuous service since. It is of 3/16-in. plate, in taper sections 4 ft. long with one double-riveted straight seam; the circumferential seams are single-riveted. The pipe at the lap of the circumferential joint is about ⅛-in. scant of the nominal interior diameter, and the rivet heads project inward to the extent of their thickness, which is about ⅛-in., the heads being flat. Rivets are pitched 1½ ins. c. to c.

The pipe joins two ends of the conduit 3,649 ft. apart on an air line. Its greatest depth below the hydraulic grade is 65 ft. It dips about one foot in four at its upper end, rises at about the same rate at its lower end, and is laid on a nearly flat profile through the intermediate distance. The length of the pipe following all its undulations is 3,666 ft.

In July, 1909, the opportunity presented itself to test the carrying power of the pipe beyond the quantity it had been required to deliver up to this time, which had rarely exceeded 30 sec.-ft.

During this test the quantity of water carried by the pipe was found by careful measurement to be 41.66 sec.-ft., hence the velocity was computed to be 2.824 ft. per sec. The discharge was measured at two permanent gaging stations by current-meters which have been in use since 1903 and have been carefully calibrated. One station is some distance above the pipe and the other directly below it. The discharge was also checked by volumetric measurement in a reservoir below.

The difference of level between the surface level of the water entering the pipe and the surface of the water at the exit was found by levels carefully run and checked to be 1.84 ft. This divided by 3,666, the actual length of the pipe, gives $s = .000502$. The hydraulic mean radius being 1.083, we have $\sqrt{rs} = .0233$, and

$$c = \frac{v}{\sqrt{rs}} = \frac{2.824}{0.223} = 121.2$$

These observations were made by Mr. William Mulholland, Chief Engineer of the Los Angeles Aqueduct.

*Assistant Chief Engineer, Los Angeles Aqueduct, Los Angeles, Cal.

A STEAMBOAT line to operate on the Missouri River between Kansas City and St. Louis was incorporated at Kansas City, Sept. 7. The incorporators include some of the same men who operated two 200-ton vessels on the river in 1907-8 to demonstrate the possibilities of the stream. It is the intention to build boats of 500 to 1,000 tons capacity, but it is uncertain whether they will be ready for the season of 1910.

TORSION TESTS TO FAILURE on large-sized shafts of wrought-iron, mild steel and nickel-steel, by Prof. C. E. Larard, at Northampton Institute, London, gave very satisfactory proof that plane cross-sections remain plane and radial lines remain straight, up to fracture. Two specimens of mild steel 3 ins. in diameter and about 12 ins. long between shoulders, turned from 4-in. bars, were drilled radially at different points along the length, and the holes filled with 1-16-in. wires or pins of brass, copper or lead. After twisting the specimen to fracture, cross-sections cut at these wires showed them to be still radial and at right angles to the axis of the bar. There were in some instances slight bends, due to non-homogeneity, but generally the pins were quite straight.

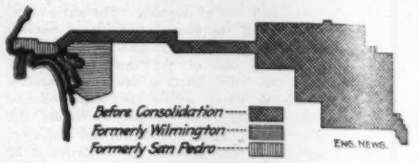
In these and the other tests of the series it was found that the mild-steel and nickel-steel specimens retained a smooth surface, remained almost perfectly round, and fractured in rather smooth planes. Those of wrought-iron roughened up markedly and developed irregularities both longitudinally and circumferentially. Axial lines scribed on the surface before testing developed into smooth spirals in the former cases, while with wrought-iron the spirals were somewhat wavy and irregular. In all cases fracture took place (under decreasing torsional moment) in a succession of stages, an outside annulus first shearing through and then others successively inward. The final fracture always was sudden, accompanied by a loud report, and evidently was a tension failure of the central core, the broken halves often shooting back into the grips.

Tests of specimens of different diameters proved the breaking moment to vary as the cube of the diameter in strict accord with theory.

These tests were reported in a paper read before the Engineering Section of the British Association for the Advancement of Science during its meeting at Winnipeg, Aug. 25-Sept. 1, 1909.

An Odd-Shaped City: New and Enlarged Los Angeles, Cal.

In its desire for municipal greatness and its aspiration to become known as an ocean port, the city of Los Angeles has recently succeeded in securing the consolidation with it of two small municipalities bordering on the Pacific Ocean. By this means it has given itself perhaps the oddest shape of any city in the world. Reference to the accompaying sketch map will show that prior to this consolidation the city already had a peculiar shape. The long strip extending oceanward, we presume, was an addition made with a view of extending the city limits to the water front. By elections held a few weeks ago, Wilmington and San Pedro, bordering on the Pacific and including the harbor of San Pedro, were added to the area of the city. This new area is about 12 sq. miles in extent and has a limited



Outline Map of the Enlarged and Odd-Shaped City of Los Angeles.

population of some 6,000, thus bringing the total estimated population of Los Angeles up to 325,000—certainly no mean city, even if the estimate be discounted considerably when the next United States census is taken.

It is interesting to note that the vote in favor of consolidation was about 725 to 225 in San Pedro; that there was also an overwhelming majority in Wilmington; and that in Los Angeles only about 100 voted against consolidation out of a total of some of 11,700.

It is reported that more than 20 miles of water frontage will be developed along the inner harbor indicated on our sketch map, and that this development will be carried out largely by the city of Los Angeles. There is also an outer harbor of great importance, so that altogether Greater Los Angeles claims that it has, at present and in prospect, one of the best deep-sea harbors in the world.

SPANISH IRON ORE sales aggregating 400,000 tons are currently reported for delivery in America in 1910. This is 100,000 more than sold for 1909. It goes chiefly to furnaces in the Schuylkill and Lehigh valleys.

THE CANADIAN LIGHT & POWER CO., of Montreal, Canada, has retained Messrs. J. G. White & Co., of New York City, for the preliminary engineering, design and supervision of construction of a 22,500-HP. hydro-electric power station on the St. Lawrence River near St. Timothee, Quebec. This power company has acquired, from the dominion government, the right to enlarge, modify and use the old Beauharnois Canal which passes south around the rapids in the St. Lawrence at Grande Isle. Just below St. Timothee at the Cedar Rapids the old canal passes within 2,000 ft. of the river bluff and here the canal will be tapped. A head of 50 ft. is thus made available. The main features of interest in the development are as follows: (1) Construction of a new canal intake and headgates, at Valleyfield, some 3,200 ft. below the old intake. (2) Enlargement of the old canal from the new intake to the forebay, a distance of 32,000 ft. This will be done to give the cross-section needed for the initial installation of turbines, by dredging the old 10-ft. channel to an 18-ft. depth, by building certain embankments and by making certain changes in highways and in highway and railroad bridges. (3) A large forebay, between the canal and the river, having a concrete head wall, of gravity section, about 40 ft. high. The side embankments will have a puddled clay core and will be some 30 ft. high. (4) A power station for four main units and two exciters. The present equipment will be of three 7,200-HP.—4,000-KW. turbine driven generators, two 440-HP.—250-KW. exciter units and three 4,000-KW. transformers. (5) A tailrace excavation for ten large units. (6) A transmission line of 27 miles to Montreal, with substation and distribution system in that city. The present development will cost about $4,000,000. The more important quantities involved, as estimated, are: Excavation, 1,243,000 cu. yds.; embankment, 387,000 cu. yds.; concrete, 45,000 cu. yds.; cribwork, 6,000 cu. yds.

Central Electric Plants in Small Towns.*

By JAMES S. KNOWLSON.†

As a class, the central stations in towns of less than 4,000 people, while representing over 65% of the total number of central stations in the country, receive but scant attention from the engineering fraternity. The problems which they must solve in order to prove a financial success are not discussed with anywhere near the same fullness of detail as are those of the large stations. In fact, it is hard to convince many engineers that such stations can possibly prove a financial success, and yet a goodly portion of them are making as great returns on the capital invested as are their larger brothers.

The smaller central station rarely owes its inception to outside capital. It is usually a direct answer to the demands of the people for those conveniences which modern existence has placed in the category of necessities. The central station may be considered in the same class with the police and fire departments; not primarily a commercial enterprise, but a local institution. As a result of this condition of affairs, municipal plants have been established in a great many small communities. That the municipal plant is rarely a success, I believe we may assume without discussion. This is not an occasion to set forth the whys and wherefores, but the fact remains that, though we may be thoroughly convinced that municipal central stations are failures, yet the number steadily increases, and every day brings reports of existing companies being threatened with annihilation by municipal agitation.

The ideal organization for a central station company in such a community is one with a wide distribution of stock, with practically every consumer owning one or more shares, and with the best business men of the town as its executive officers. Such an organization gives all the advantages of a municipal plant, makes the company a matter of local pride and almost a public institution, and at the same time guarantees that it will receive the hearty cooperation of the people as a whole, and the attention which the best business men can give it.

But, turning from the subject of company organization, the problems of location and equipment demand first consideration.‡ In all discussions as to the requirements of such stations two facts must be kept constantly in mind. First, that the amount of available capital is always very limited; that $100 frequently means 1% of the entire first cost of the plant. Second, that the equipment must be extremely simple; that it must not be such as to demand expert care, and while many refinements may show, on paper, a fuel economy sufficient to warrant their use, the additional apparatus necessary so complicates the operation of the plant, raises the standard of attendance and adds to maintenance cost and chances of trouble.

LOCATION.—The station should be situated as near to the railroad or local point of fuel supply as possible. It should also, if possible, have available a water supply free from lime or other solid material in suspension or solution, and of such quantity as to make condensing feasible. For even though the station will probably start non-condensing, the natural growth will in time raise it to a size where it will pay to condense.

Enough ground should be obtained to provide space for extensions for store room and for stables. If, in addition to fulfilling these requirements, the location is reasonably close to the center of distribution, it may be declared ideal, but this last qualification is not as important as the others.

LAYOUT.—Fortunately, or unfortunately, the small-station engineer seldom has to worry about limited floor space. Land is cheap. The result has been in such stations that we find very little consideration given to compact arrangement, and buildings, as a rule, are far larger than is necessary and often extremely inconvenient.

The power-house arrangement for such a station should combine three qualities: simplicity, convenience for operating purposes, and susceptibility to economic extension; which last means a parallel boiler and engine room. Fig. 1 shows an ideal layout for a small central station of 100-KW. capacity, using simple non-condensing high-speed engines belted to 50-KW. generators.

In such a station the engineer will have as a fireman a rather unreliable helper, and at times he will probably act as fireman himself. With an arrangement as shown here, the engineer may stand in front of his switchboard and from that position be in full view of the gages on the end of the boiler, and from the boiler room he may still be in full view of his switchboard. Further, it is but twelve short steps from the firing floor to the engine room.

The station is provided with many windows, making it light and airy. Ample space is allowed on all sides of the generating apparatus, rendering it easily accessible. The steam piping is of the most economical length and interconnected, permitting the utmost flexibility, and the auxiliary apparatus, heater and boiler feed pump are conveniently located.

In the boiler room sufficient space is allowed for cleaning boilers, and coal storage—always an important item—is taken care of in a most simple manner. The coal is unloaded from cars into a bin at the end of the boiler room, and is fed automatically to the firing floor through an opening in the base of the building, or may be wheeled in through the large doors at either end, which also permit a ready exit for ashes. With such an arrangement the natural extension will cause the boiler and engine room to grow side by side.

APPARATUS.—In stations of the capacity under consideration, return tubular boilers are generally installed; for, while water-tube boilers are capable of better economies, the efficiency of a boiler plant rests heavily upon the methods of firing, and higher first cost of water-tube boilers seldom pays for their use in such stations.

The average first cost of horizontal return-tubular boilers varies from about $17.50 per boiler HP. for a 40-HP. boiler to $11.75 for a 140-HP. installation.* This includes settings, but does not include stack or auxiliary apparatus. The price of water-tube boilers varies so radically that no general figures can be given, but their first cost is always materially higher than that of the return-tubular type.

The first cost of brick stacks varies from $700, for a 100-HP. boiler room, to $1,500 for a 310-HP. plant. Iron stacks range between $100, for a 100-HP. plant, to $325 for a 380-HP.* While the first cost of an iron stack is materially less than that of brick, the up-keep is much greater. What this up-keep will be, and what length of life may be expected with an iron stack, are factors largely governed by local conditions; the humidity of the atmosphere, and the like. But even with a comparatively short life and high maintenance charge, the iron stack commends itself in the case of the small plant, because it may be so cheaply replaced by a larger stack to take care of increased station capacity.

In the engine room, the problem of whether the station shall be operated condensing or non-condensing must first be discussed. The decision rests largely on the capacity of the station, nature of the load, price of fuel, the availability of water; all local conditions, but it is generally true that in small stations it seldom pays to condense, on account of the increased complications in operation. Assuming that the plant will operate non-condensing, turbines or simple high-speed engines, either direct-connected or belted to generators, are to be recommended. A simple Corliss type engine, while showing much better economies at full load, is seldom as efficient on light loads as a high-speed engine, and, further, its first cost with the necessary foundations and jack shafting is far greater than that of the high-speed engine.

From an engineering standpoint, direct-connected apparatus should always be used; but it must be remembered that floor space is not an item, that in small-capacity units belt troubles and belt losses are not such serious factors as in larger sets and that the item of first cost favors belted apparatus. A high-speed simple engine set, direct-connected, costs from about $2,250, for a 50-KW., to $5,000 for a 150-KW. A similar belted set would cost from about $1,750, for a 50-KW., to $4,250 for a 150-KW.* Turbines, comparing favorably with direct-connected sets, are to be recommended on the score of better continued efficiency, and also on account of the fact that the exhaust is free from oil and may be used directly for other purposes.

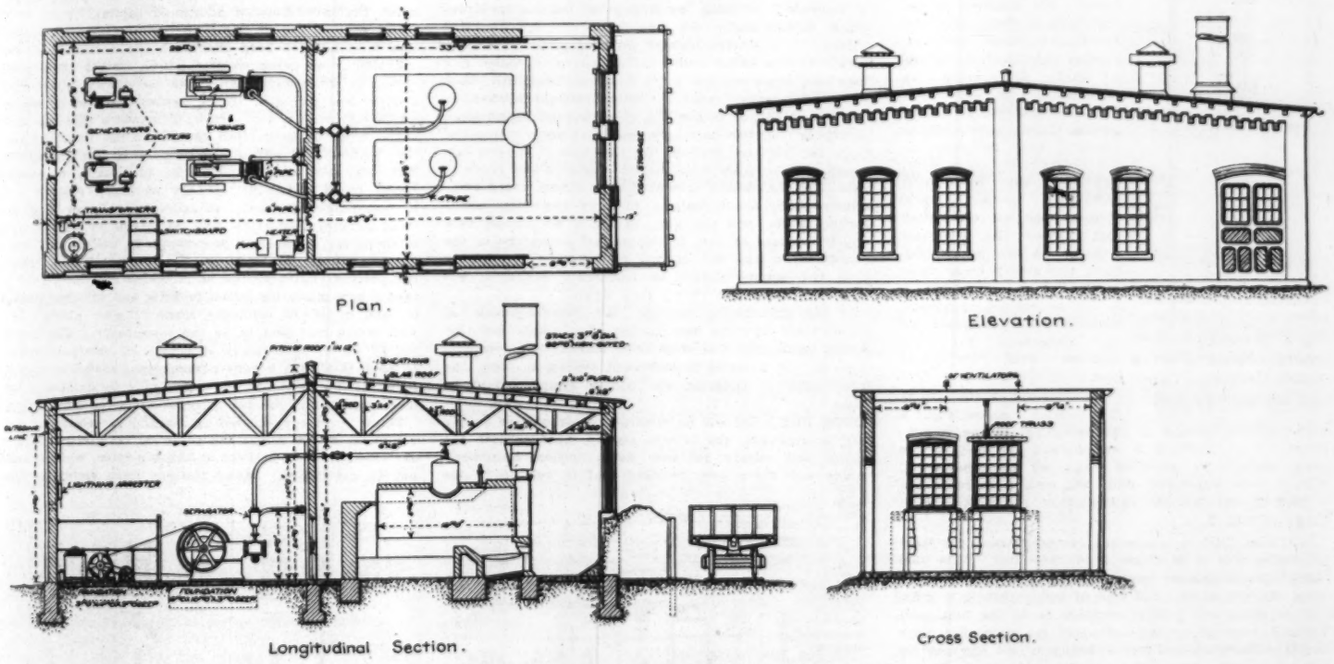


FIG. 1. LAYOUT OF A TYPICAL 100-KW, 2,300-VOLT, THREE-PHASE, STEAM POWER PLANT.

*Parts of a paper read before the convention of the National Electric Light Association, at Atlantic City, N. J., June 1.

†Lighting Department, General Electric Co., Schenectady, N. Y.

‡This paper deals only with the station using steam boilers and engines.

[*In the original paper by Mr. Knowlson, these costs were given by curves which departed slightly from straight lines. In the case of the horizontal boilers the average of maximum and minimum is about 7% above the curve. In the cases of brick and iron stacks the middle range of the author's curve was about 10% greater than an average of these figures would give. With engines and generators there was practically no variation.—Ed.]

It hardly seems necessary to say that the generators for such a plant should be alternating-current, 60-cycle, polyphase machines. The average small station is located in a community loosely knit, with residences straggling out for a considerable distance, and a large amount of copper is necessary in 25-KW. feeder circuit, in order to obtain a satisfactory distribution for 220 or 110-volt direct-current, compared with the amount necessary for 2,300-volt alternating-current. However, if the greater portion of the load is in the immediate vicinity of the central station, alternating current may be generated at 220 volts and distributed on a 3-wire system with 125 volts between the outer and neutral, and transformers may be used for stepping up this voltage in order to serve outlying districts economically.

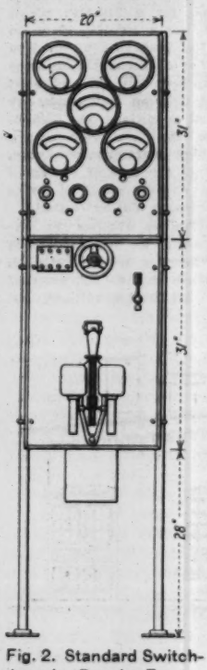


Fig. 2. Standard Switchboard Panel For a Small Generator Carrying a Lighting Load.

The switchboard in such a station must be of the simplest type. Cheap boards are always poor economy, but complicated arrangements are unnecessary. The design of the board and its equipment depend entirely upon the kind of service rendered. For example, a station with a single generator carrying a street and commercial lighting load requires a single panel (Fig. 2), carrying on its upper section instruments for commercial and street-lighting circuits and switches for the control of the series street lighting. On the lower section it carries a field rheostat and an oil switch that throws the generator directly on the commercial lines, this switch being made automatic as a protection to the generating apparatus. Such a panel combines all the functions in such stations with low first cost.

Any increase in the size of the station necessitates a corresponding increase in the equipment of the switchboard. Fig. 3 shows a switchboard for one of the larger stations in the class which we are considering, with a more diversified load; but such a board is but a normal and natural extension of the single panel shown in Fig. 2.

DISTRIBUTION.—Outside the central station, the largest single item of first cost is the pole line. This item depends so largely on local conditions, such as price of labor, quality of soil and cost of poles, that it is difficult to make any general estimate as to the first cost. Table I, however, shows estimates for such pole lines in six different localities. Painting is not included in these estimates, but will range from 25 cts. to $1 per pole, depending upon the locality. It will seldom be necessary to use poles of more than 30 ft. in length, and often 25-ft. poles may be used to advantage.

In arranging the secondary distribution, every attempt should be made to install transformers in as large capacity units as possible. The saving in price and in core and copper losses, which may be effected by using a single unit in place of several small ones is shown in Fig. 4; the saving thereby being, of course, balanced against the amount of copper necessary in the secondary lines.

STREET LIGHTING.—Until recently, street lighting has meant arc lighting. To-day, however, while arc lamps unquestionably provide the best illumination in business districts and wherever they may be so hung as to allow for the proper distribution of their light, the series tungsten lamp is to be recommended for residential and suburban lighting where shade trees prevent the proper hanging of arc lamps, or where a large quantity of light is neither wanted nor required. Table II. shows the first cost and operating expense of magnetite-arc lamps and series tungsten lamps in various capacity units. It also shows the number of incandescent units necessary to provide the same street illumination as one arc. Arcs and series tungsten lamps may be operated on the same circuit, and the combination of a few arcs with a relatively large number of incandescents will probably provide the most satisfactory street illumination in the average small town.

Passing from the construction and design of the new central station, we approach the questions of operation and the methods whereby the greatest possible returns may be obtained on the invested capital. The consideration of this question naturally divides itself under four

TABLE I.—POLE-LINE COSTS PER MILE FOR 3-PHASE, 2,300 OR 6,600-VOLT.

No.	Item.	Omaha.	Kansas City.	Montana.	Minnesota.	Texas.	Tennessee	...rage.
50	30-ft. poles	$275.00	$287.50	$200.00	$200.00	$171.00	$180.00	18.90
50	Pole hardware	10.00	7.10	16.00	12.50	8.30	7.40	10.25
50	Cross-arms, 2-pin	17.50	7.25	11.50	15.00	17.00	16.00	14.00
150	Insulators	16.50	6.00	11.20	6.00	6.75	7.00	9.00
	Labor setting	80.00	90.00	200.00	125.00	55.00	100.00	60.00
	Labor stringing wire	25.00	15.00	40.00	50.00	30.00	40.00	35.00
	Incidentals	25.00	41.00	50.00	30.00	10.00	20.00	30.00
	Total	$449.00	$453.85	$528.70	$438.50	$297.05	$370.40	26.15

These figures do not include painting and are exclusive of bookkeeping, overhead charges, and the ...

heads: (1) Economies and Improvements in Operating Conditions; (2) Addition of New Business; (3) Broadening the Scope of the Plant; (4) The Extension of Service to Outlying Communities.

ECONOMIES AND IMPROVEMENTS.—There are two points which are to be strongly emphasized. First, the necessity of keeping records that will show the cost of production: not complicated records, but adequate records. Such a statement seems trite, but there are many plants that possess only the sketchiest sort of books. There is no station so small that it should not possess means of telling exactly how much its power costs. Every station should possess a recording wattmeter, measuring the total output; should record the fuel, water, supplies, labor and incidentals, month by month, and should keep this record in such form that it may be easily compared. The second point to be emphasized is that in attempting to improve operating conditions a definite program should be followed.

Regular inspections should be a part of the day's work. In the boiler room, the repairing of boiler settings and improvements in methods of firing will often bring phenomenal results. Boilers should always be operated at full or overload if possible, and experiments should be carried on, varying the number of boiler units for various portions of the load. Experiments should also be made with various qualities and types of fuels, and the results tabulated. In almost every community there are industries such as sawmills, woodworking mills, and the like, having a by-product that may be utilized as fuel to the mutual advantage of the manufacturer and the central station. In the engine room the engine should be frequently indicated, the valves set, belts and piping kept tight.

In the distributing system, the rearrangement of transformers and the substitution of a single unit for several small ones will often show marked improvements (Fig. 4). If a series incandescent system is used, the substitution of tungsten for carbon lamps should be made.

NEW BUSINESS.—If no electrical contractor or supply man is available, the central station must go into the wiring and supply business itself, wiring customers' houses and every new building that is put up in the town. Concessions should be made on the first cost of wiring. The total cost being spread over a number of months, perhaps a year, on such a basis practically every house in the town can be wired. But in approaching the prospective customer with such a proposition, a concrete estimate of the cost should always be made. General terms should be avoided, and he should always be talked to in dollars and cents.

Simple advertising by one or more methods is well worth while. Manufacturing companies are always glad to supply pamphlets and interesting reading matter on electrical devices, free of charge, to the central station for distribution among its customers. The windows of the company's office should always be illuminated.

Probably the best advertisement is a continuous service to satisfied customers, but, if for any reason service is interrupted, the management should take the earliest possible opportunity to explain the cause to the public without waiting for some one else to tell the story.

TWENTY-FOUR-HOUR SERVICE.—Within the last year the statement has been frequently made that any place which could support electric service of any kind will support a 24-hour service. This is unquestionably true in almost every community. The operation of a plant for 24 hours a day, while increasing the fuel and labor charges, does not materially increase the maintenance and overhead charges on the plant, or demand the investment of additional capital.

The general use of electricity is increasing so rapidly that it is hard to keep pace with the development, and arguments for using electric power, rather than small steam or gas-engine units, are constantly growing in number and strength. From figures obtained in five or six towns with a day circuit, it appears that for each horse-power of motor load carried on the lines the central station may expect the sale of approximately 750 KW.-hrs. per annum. This is, of course, a general figure based upon the average of small motors used in many different lines. In soliciting a motor load, the same general injunction may be given as in the case of lighting. A concrete proposition in dollars and cents should always be made to the prospective customer. His present engine should be indicated and he should be shown how much his losses in belts and friction amount to, and a definite estimate made of what electric service would cost him to do the same work. The pumping of water, particularly if a tank or reservoir system is used, is always a very advantageous load and may be taken at low rates, as the water may be pumped at almost any time of the day or night when the load is light.

There is an ever-increasing demand for electrical conveniences in the home, and these, in themselves, form a day load generally paid for at lighting rates, which should not be overlooked. Many stations have estimated that flatirons alone will bring a revenue of $7 to $10 each annually.

BROADENING THE SCOPE OF THE PLANT.—To broaden the scope of the small central station and incorporate under the same management all the public utilities of the community should be the ideal of every manager. Water and ice are both desirable additions, particularly in the southern and southwestern sections, the greatest demand for these commodities, coming as it does in the summer, when the lighting load is small-

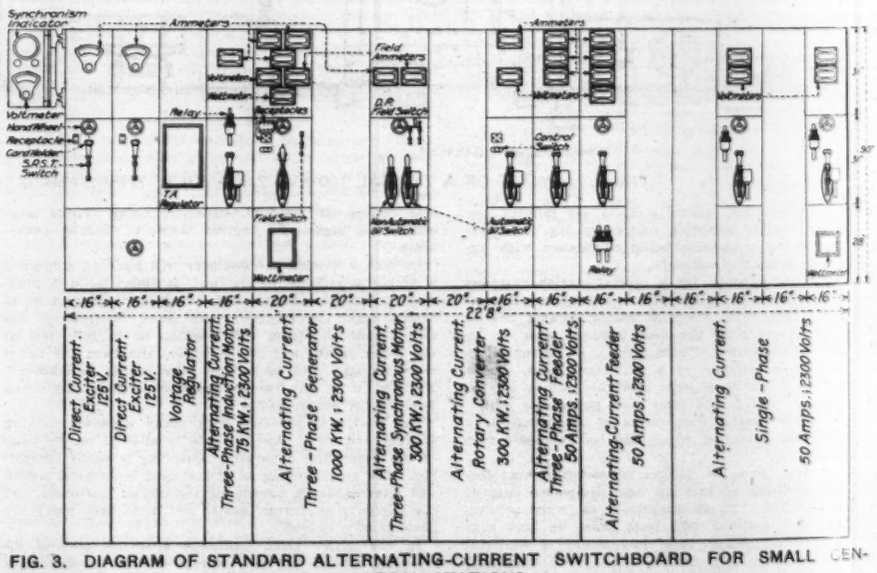


FIG. 3. DIAGRAM OF STANDARD ALTERNATING-CURRENT SWITCHBOARD FOR SMALL CENTRAL STATIONS.

TABLE II.—COST OF STREET LIGHTING IN VARIOUS UNITS.

Unit.	Magnetite 4-Ampere Arc.	Tungsten 40-Watt.	Tungsten 60-Watt.	Tungsten 100-Watt.	Tungsten 200-Watt.
No. of units giving street illumination equivalent to one arc	1	4	3.21	2.48	1.76
First cost per unit, including brackets, transformers, etc., on a basis of equipment necessary for illumination equivalent to 100 4-ampere Magnetite arcs	$54.00	$10.96	$12.00	$11.60	$15.70

OPERATING COST, BASED ON 4,000 HOURS BURNING PER YEAR.

Unit.	Magnetite 4-Ampere Arc.	Tungsten 40-Watt.	Tungsten 60-Watt.	Tungsten 100-Watt.	Tungsten 200-Watt.
Maintenance and renewals	$6.00	$3.60	$3.80	$4.20	$4.67
Interest, 5%	2.70	.55	.68	.58	.80
Depreciation, 5%	2.70	.49*	.57*	.52*	.73*
Current at 2 cts. per KW.-hr.	27.50	4.00	6.00	10.00	20.00
Total per annum	$38.90	$8.64	$11.05	$15.30	$26.20

*Exclusive of cost of lamps.

These figures are exclusive of repairs on overhead equipment, inspection cost, clerical, storeroom cost, and the like.

report said: "The committee has not been able to discover any of the ravages from the use of white lead attributed to it by the labor unions. The death rate among house painters is very low, averaging only 1 in every 7,000 or 8,000 painters." The report declared that the mortality among house painters was large only where there was an excessive use of alcohol.

The bill to prohibit the use of white lead introduced in 1906 was defeated, but another bill for the same purpose was introduced at once. It was enacted by the lower house of the French Congress in 1907 and was discussed in the Senate and by joint committee from time to time until July 13, 1909, when it became a law.

The point upon which the two houses differed was whether an indemnity should be allowed to manufacturers of white lead for damages they might sustain from the loss of a market for the goods they had on hand. The law as finally passed prohibits the use of white lead in painting of buildings, inside or outside, after the expiration of three years. It is calculated that within that time the manufacturers will be able to dispose of their product on hand so that no loss will accrue. [Copy of the law may be examined at the Bureau of Manufactures, Washington, D. C.]

THE FIRE PROTECTION EQUIPMENT of the Pennsylvania Railroad has been extended and equipped so that the 1,397 fires occurring during 1908 on railroad property valued at $260,000,000, gave an aggregate damage of only $346,149. Of these fires 274 were extinguished by railway employes with railway apparatus and with only slight loss. It is claimed that the railroad has been working to this end for some 30 years and that as a result the system of fire protection along its lines is the most extensive similar undertaking made by any private corporation.

There are 423 locomotives equipped with fire-fighting apparatus. These are used continually in yard service at various points on the company's lines and are available at all hours of the day and night. On signal, their crews, all of which have been trained in fire fighting, hurry their engines to the fire, all tracks being cleared so that no time is lost. So successful has this protection of

est. The advantage of adding an ice plant to the central station equipment is only beginning to be thoroughly appreciated. The existing boiler capacity is in almost every case adequate. The engine-room and boiler-room force, if the plant offers a 24-hour service, need not be increased, and only one additional man is required as an ice-maker during the summer months.

Another method by which a central station may increase its load is along the lines of extending its service to outlying communities. For years the larger companies have been pushing out their lines to greater distances from the central station, profitably serving communities which in themselves are too small to support a central station.

Two general plans have been followed in supplying such service. The first and simplest method is the formation of a local company in the community to be served and the supplying of power to this company at wholesale rates from the transmission line to the central station. This plan has much to commend itself. The company is a matter of local pride, and it removes the burden of obtaining a franchise, of maintenance, repairs, and the like, and reduces the amount of capital necessary to the bare cost of the transmission lines.

The second method of approaching such a proposition may be termed the straight substation system; the central station company owning pole lines and distributing system and operating them as part of their own plant. The tabulation given in Table III. shows the total investment and margin of safety and profit that may be expected from such extensions to communities of different populations at varying distances from the central station. It also shows the most economical voltage at which the transmission may be carried out.

CONCLUSION.—The general impression, that a small central station cannot possibly be a sound financial proposition, is unquestionably erroneous. Table IV. shows the gross revenue in a number of typical central stations, ranging from stations supplying electric light alone to those furnishing light, water and ice. They are all prosperous and their owners are well satisfied; but the rank and file of successful small stations do not advertise their success, and it is hard to persuade them that what they are doing can possibly be of interest to others.

The failures, though comparatively few in number, are much better known, but an investigation of the reasons that caused these failures show that there were generally two factors that mitigated against the success of the plant: first, overcapitalization, and, second, inefficient machinery.

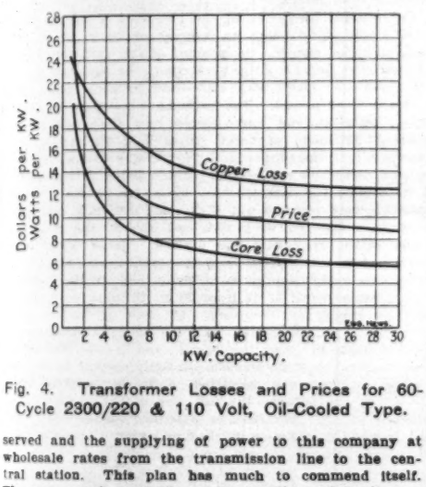


Fig. 4. Transformer Losses and Prices for 60-Cycle 2300/220 & 110 Volt, Oil-Cooled Type.

TABLE IV.—REVENUE CHART OF TYPICAL SMALL CENTRAL STATIONS.

Location.	Population.	Capital.	Revenue: Ice.	Revenue: Water.	Revenue: Electricity and supplies.	Total per capita.
New Jersey	4,000	$30,000 stock	.....	....	$10,909.42	$2.60
Illinois	1,000	$12,000	.....	....	2,900.00	2.90
Kentucky	1,800	$7,500 stock, $5,500 bonds	.....	....	6,145.72	3.41
New York	1,300	$12,000 stock	.....	....	5,504.16	4.25
Ohio	1,800	$20,000 stock	.....	....	8,300.00	4.60
Illinois	2,000	$10,000	.....	....	7,563.98	3.78
Illinois	2,700	$25,000 stock, $12,500 bonds	.....	$720	8,353.80	3.36
Indiana	860	$10,000	.....	320	3,952.00	5.00
Ohio	1,900	40,000	.....	3,745	7,235.20	6.10
Kentucky	1,900	40,000	$4,945.52	1,270	7,933.00	7.85
Iowa	4,000	.....	12,000.00	$5,600, steam heat'g	38,300.00	14.00

WHITE LEAD FOR USE IN PAINTING has been prohibited by an act of the National Legislature of France. The following information on the subject from U. S. Consul John C. Covert, Lyons, has recently been published in the U. S. Consular and Trade Reports:

Six months ago this consulate reported that the labor unions of France had unanimously petitioned the Congress to prohibit the use of white lead in paint, alleging that it was very injurious to health. The Congress referred the question to a special committee, which made a thorough investigation of the subject in 86 of the 88 departments of France, as well as in Algeria and Tunis, and reported that of 194 journeymen painters who were sick in the hospitals investigated in 1904 only 27 were sick from diseases caused by the use of white lead. The

TABLE III.—SMALL SUBSTATION EXTENSIONS TO OUTLYING COMMUNITIES.

Population served.	Capacity of substation.		Distance of substation from city limits: 3 Miles.	6 Miles.	9 Miles.	12 Miles.
500	25-KW.	Total investment.	$4,800	$7,500	.....	.....
		Margin of safety and profit.	11.5%	3.7%	.....	.....
		Transmission.	2,300 volts 3-phase	2,300 volts 3-phase	.....	.....
1,000	60-KW.	Total investment.	$7,600	$10,000	$12,000	$14,200
		Margin of safety and profit.	21%	13.5%	10%	5.5%
		Transmission.	2,300 volts 3-phase	11,000 volts 3-phase	11,000 volts 3-phase	11,000 volts 3-phase
1,500	100-KW.	Total investment.	$10,000	$12,200	$14,000	$16,300
		Margin of safety and profit.	25%	18.7%	13.9%	10%
		Transmission.	2,300 volts 3-phase	11,000 volts 3-phase	11,000 volts 3-phase	11,000 volts 3-phase

property at out of the way places proved, that an additional number of yard engines are now being similarly equipped.

Some adequate protection is installed at every station and terminal. At the important points elaborate systems have been devised with net works of fire mains. At Altoona, Pa., the center of the Pennsylvania system, a high-pressure water-supply system has been installed for fire-protection only and without feed connections to any other distribution pipes. This has been considered necessary in view of the possibility of a fire seriously interfering with the operation of the road. This insurable value of the machine and car shops is about $6,000,000 exclusive of the shops at Juniata, a couple of miles away, where many locomotives are built. There are two fire-engine companies of some 32 regular firemen and 31,000 ft. of rubber-lined cotton hose is available. Distributed about the works are chemical engines and extinguishers, sand and water pails, hose in racks, ladders, etc. There are laid seven miles of large water mains with 72 two and three-way hydrants so that 184 streams can be made. To guard against loss of pressure, by breakages in the main or by mud and other clogging troubles, the company has laid parallel mains, under the shops and equipment yards, with proper gate valves so that any part of a broken or clogged main can be cut off and so as not to prevent flow to hydrants on other parts. In the Pottsgrove Hills, back of Altoona, a reservoir has been created to dam up some 180,000,000 gals. of water which is available for fire-protection in times of severe drought. The high elevation of this reservoir gives the system a good static head for emergencies, and one which cannot be diminished by the breakdown of any pumping plant or fire engine.

On account of the congested areas in the machine shops, it has been necessary to erect four-story buildings. These structures are over 100 ft. high, but by joining two streams, with a "Siamese" coupling, into one, a 2-in. stream of 400 gals. per min. can be thrown to the top.

The Lethbridge Viaduct Over the Belly River, Canadian Pacific Ry.*

By J. E. SCHWITZER.†

The Crow's Nest line of the Canadian Pacific Railway branches off the main transcontinental road at Medicine Hat, and parallels it through the mountains a hundred miles to the south, to give easy access from the east to the rich mining regions of southern British Columbia.

The old line between Lethbridge Junction and MacLeod is 37 miles in length; the distance from Lethbridge, which is situated on a spur track, to Lethbridge Junction is 1.5 miles, the total distance from Lethbridge to MacLeod being 38.5 miles. The present line is constructed with curves as sharp as 7° and with a grade of actual 1%, no compensation being allowed for curvature, so that in the estimates for new location the ruling gradient on this line was calculated to be equal to a virtual 1.2% grade.

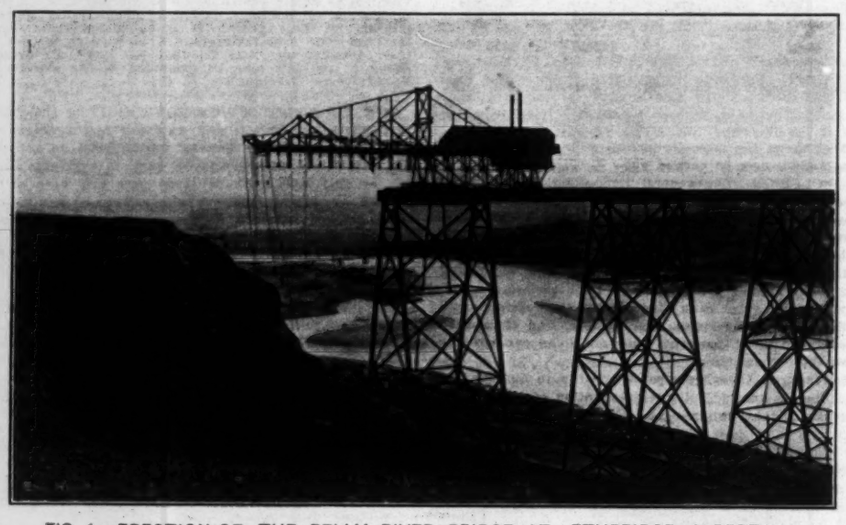


FIG. 1. ERECTION OF THE BELLY RIVER BRIDGE AT LETHBRIDGE, ALBERTA.

On the above line, which was constructed in 1897 and 1898, are twenty wooden deck-bridges, with a total length of 12,063 ft., 1,450 ft. of this length being Howe truss spans, varying in length from 100 ft. to 150 ft. In the majority of cases these bridges cross streams and ravines with very steep-cut banks, which, on account of the nature of the soil, require constant watching, especially in the spring and during high water. The worst of these crossings are those at St. Mary's and Belly rivers. On account of the life of these bridges being very nearly expired they would require during the present year heavy repairs or practically rebuilding. The estimated cost of permanent bridges to replace these wooden bridges is $1,065,000.

NEW LINE.—Owing to the necessity of rebuilding these bridges, and to the rapid increase of traffic, and the fact that the original charter for the Crow's Nest branch required the construction of a line to start from Lethbridge, it was therefore decided to have surveys made and ascertain if it were possible to secure a low-grade line with better alinement.

With this object in view extensive surveys were made in 1904 and 1905, the line which was finally adopted being as shown on the map, Fig. 2. This line gives a maximum virtual grade of 0.4% (21.12 ft. per mile) with a maximum curvature of 3°.

As already noted, the town of Lethbridge is on a spur track of the Crow's Nest Pass Ry., 1.5 miles long, which necessitates practically all trains running into Lethbridge and backing out, being a loss of 3 miles, which will be saved when the new line is placed in operation. The saving effected by the new location as compared with the old is as follows:

5.26 miles of line, 1,735° less curvature, 37 fewer curves, and 401.5 ft. less rise and fall, besides securing the 0.4% grade as compared with a virtual 1.2% on the old line. These changes should so reduce operating expenses that the saving with an increase of 20% in traffic above last year would pay an interest at the rate of 4% on an investment of $3,625,000, besides which it would cost to replace the old bridges with permanent structures $1,065,000. The total capital expenditure which would therefore be justified would be $4,690,000, while the estimated cost of the change of the line is $2,048,700.

On this new line there are only two bridges, both large viaducts, one over the Belly River at Lethbridge, 5,327.6 ft. in length, with a maximum height of 314 ft. from the bed of the river. This viaduct is the subject of this article. The second bridge, over the Old Man River, is 1,900 ft. in length and 146 ft. in height from the bed of the river.

SITE.—The east end of the viaduct is 3,800 ft. west of Lethbridge Station, being somewhat west of the center of the town. Lethbridge is the center of a large irrigation tract and of an important coal-mining district, is a divisional point of the Crow's Nest branch of the Canadian Pacific Ry. and the Alberta Ry. & Irrigation Co., and has at the present time a population of about 6,000. It is located in the province of Alberta, 759 miles west of Winnipeg, 2,174 miles west of Montreal, and is the center of a rapidly-developing territory.

The site of the bridge is the best for a high-level crossing in the immediate vicinity of the town. The slopes are fairly uniform for a distance of 1,000 ft. from the prairie level, then drop more abruptly for 800 ft. to the flat, which is flooded in extreme high water, then on an approximate level for a distance of 1,800 ft. to the edge of the river, which is 300 ft. wide. On the west side of the river it rises rapidly to prairie level in a distance of 1,300 ft.

On the east bank the soil is clay and gravel for about 6 ft. from the surface, then 50 ft. of hard clay, 12 ft. to 20 ft. of coarse gravel, and below this shale and coal.

In the bed of the river there is about 20 ft. of gravel, then 20 ft. of coal-shale, below that 2 ft. of blue clay, then a hard shale for a distance of 16 ft. to 18 ft., below which is hardpan and sandstone. The west side is of somewhat similar formation, but the bank has been eroded, causing it to cave in at several points, which makes it necessary to do extensive work in order to secure proper foundations for the bridge.

The alinement of the bridge is a tangent throughout, there being a 1° curve at the east approach of the bridge, and a 3° curve at the west approach; the grade is 0.4% rising to the west for the whole length of the bridge.

On the east side of the bridge there are some old mine workings which followed a vein of coal 7 ft. thick which was worked out in 1888 to 1890. This vein of coal was practically horizontal, and level with the flat at the river, varying from about 25 ft. at bent No. 23 to 150 ft. below the surface at the east end of the bridge.

The work of finally laying out the center line and locating the position of the pedestals for the viaduct was commenced during the first week of December, 1907.

SUBSTRUCTURE.—The contract for the excavation and substructure of the bridge was awarded to J. Gunn & Sons, of the City of Winnipeg, the work to be completed by March 1, 1908. The excavation work was started in October, 1907, and the concreting was commenced in November, 1907, and carried on continuously, being completed in February, 1909.

Before excavation was started borings were made at various points along the bridge site; results of these are shown in Fig. 4. In addition to this several test-pits were sunk and test-piles were driven. The several test-piles consisted of fir piles about 11 ins. in diameter driven to a depth of 24 ft. to refusal, and afterwards loaded with a 30-ton load and shown settlement.

In order to make absolutely sure of the foundations near pier 23 a shaft was sunk to the old mine workings. In the sinking of this shaft we met with a couple of fatalities by men going in and being overcome by the accumulation of gas. They went down to rescue a small boy who was playing in the shaft after being repeatedly warned not to go near the place.

Considerable difficulty was experienced with the river piers, as it was found necessary to go down through the gravel and shale, making it very difficult to get tight cofferdams. In June, 1908, before the excavation for these piers was completed, there was a flood, during which the water rose to a higher level than had ever been known at this point, being 1 ft. higher than previous extreme high water, which occurred in June, 1902. This high water completely submerged the cofferdam, carrying enough silt to fill them, besides which it carried away some of the contractors' plant, causing delay in the completion of the work. All the pedestals and foundations on land were completed by Aug. 31, 1908.

FOUNDATIONS.—For the foundations of the bridge various estimates were made in connection with the cost of timber piles and concrete piles, with the concrete pedestals on top. It was finally decided to adopt concrete piles and concrete pedestals, and a contract was let on this basis. All the land piers, with the exception of six, were built on concrete piles, the excavation for the same averaging 7 ft. deep, but in some cases running as deep as 18 ft. The length of the concrete piles varied from 12 ft. to 20 ft.

The greater part of the concrete for the piers was mixed with a three-quarter-yard Smith mixer, and conveyed from the mixer to the piers in ordinary contractors' dump-cars.

The general formation of the river-bed is gravel over hard shale, there being an average of 10 ft. of water, then 10 ft. of gravel. On account of the hard formation of the river-bed no piles were used; the excavation for the piers was made with clam-shell buckets before the caissons were placed. The caissons were made of 10 × 10-in. material, and were floated into place and sunk; sheet-piling made of three pieces 2 × 10 ins. nailed together to form tongue and groove was driven outside caisson, a second row of sheet-piling being driven about 3 ft. outside the first to leave space for puddle. These caissons were pumped out with some difficulty, and the excavation finished with pick and shovel, the material being raised by bucket and derrick. These centrifugal pumps were required to keep the foundations dry. Excavations were made to hard shale, and drillings made to a further depth of at least 20 ft. to make sure there was no change of formation. In three of the piers it was found that the pumps could not hold the water down long enough to erect the forms, and it was therefore necessary to have the bottoms carefully cleaned by divers before concrete was deposited; 4 ft. of concrete was placed in the bottom, the full size of the caisson, and allowed to set. The caisson was then pumped out and the balance of the pier finished as usual.

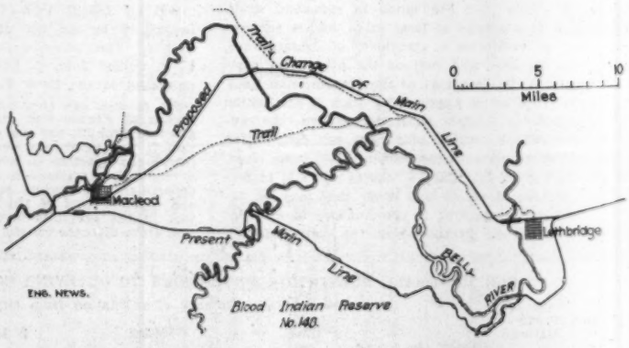


FIG. 2. SKETCH MAP OF OLD AND REVISED LOCATION OF CROW'S NEST BRANCH, CANADIAN PACIFIC RY., BETWEEN LETHBRIDGE AND MACLEOD.

On account of the steep side-hill special pile-drivers had to be made for driving concrete piles.

Owing to the nature of the west slope all foundations were carried down to such a depth that if the ground takes a natural slope, the foundations will be well below it, besides which the ground in the immediate vicinity of the piers was sloped. In addition to this, in order to keep water away from the west bank a reinforced-concrete retaining wall has been built, strong enough to withstand the pressure of saturated quicksand. This was adopted altogether as a precautionary measure.

Piles were driven up-stream from the piers on the flat to catch any drift-wood which might come down in the

*Abstract of a paper read before the Engineering Section of the British Association for the Advancement of Science at Winnipeg, Man.

†Assistant Chief Engineer, Western Lines, Canadian Pacific Ry.; Winnipeg.

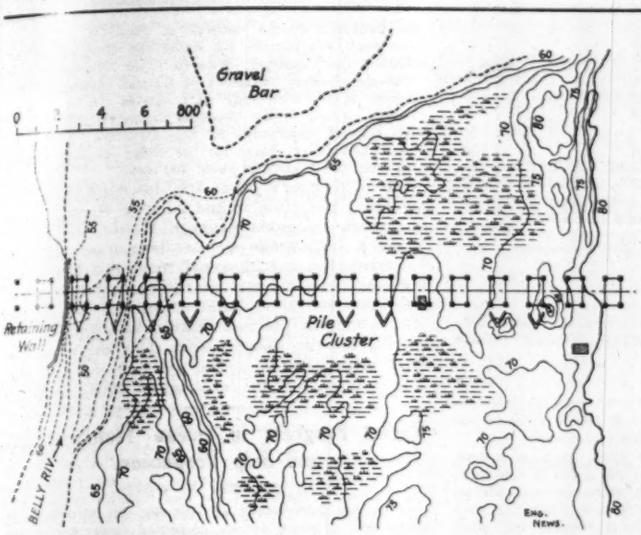


FIG. 3. CONTOURED PLAN OF BELLY RIVER VALLEY AT SITE OF LETHBRIDGE VIADUCT.

flood and lodge in the steel-work, and it is further intended that booms will be anchored up-stream in the river which will deflect any debris through the 100-ft. openings.

DESIGN.—Numerous preliminary studies were made in connection with this structure and the design finally decided upon consists of 44 plate-girder spans 67 ft. 1 in. long, 22 plate-girder spans 98 ft. 10 ins. long, and one riveted deck lattice truss span 167 ft. long, carried on 33 rigidly braced riveted steel towers. The distance center to center of columns in each tower was made 67 ft. 3 ins., and the distance center to center of columns in adjacent towers 100 ft. The tower spans were made 67 ft. long, in order to give longitudinal stiffness to the towers, and reduce stresses in the tower legs. A batter of 1 in 6 was given to the legs, which, with the spacing of the girders of the spans at 16-ft. centers, gives ample spread at the base of the towers to keep the uplift at the piers within a reasonable amount; 100-ft. intermediate spans between towers were decided on for that portion of the structure over 125 ft. high, these spans being the longest thought feasible to handle, from an erection standpoint, although theoretical economy would call for still longer intermediate spans.

On account of the severe winds experienced in this region, and considering the great height of the structure, it was decided to use through plate-girder spans instead of decks on this viaduct, so as to render it practically impossible for cars to leave the deck from derailment or wind and give greater security to the viaduct, since a derailed car might fall and knock out tower legs and bracing, on account of the great batter of the bents, and cause great delay to traffic. This type of span has since been adopted for a similar high viaduct in New Brunswick.

In order to take care of the uplift from wind the columns were securely anchored to the piers by means of four 2½-in. bolts built into the piers to such a depth as to engage a mass of masonry weighing 1½ times the uplift. Special steel castings were designed to secure the bases of these columns to the anchor-bolts, and between the shoe-plate and bed-plate the Canadian Pacific Ry. standard disk-bearing was used, so as to provide for proper bearing in the event of the masonry not being absolutely level. Contraction at the base of the towers was taken care of by fixing one corner and allowing the other three corners to slide on the bed-plates. This was arranged by making 5-in. holes in the steel casting, shoe and disk-plates. At the fixed corner a hollow cast-iron cylinder was placed around the bolt, filling up the hole. At the other three corners, where movement takes place, a piece of steam pipe was placed around the bolts, having a length of about ⅛-in. greater than the distance from the top of the bed-plate to the top of the steel casting, so as to allow the washer of the anchor-bolt to bear tight on this filler, which, in turn, bears on the bed-plate, and allows sufficient slack between the underside of the washer-plate and the steel casting for the latter to move. Dry graphite was placed in the recess of the bed-plates in which the disk-plates rested, to act as a lubricant. Tongues were made on the bed-plates at two corners of the towers, and the fourth bed-plate was made without any tongue, with the idea of its moving in a diagonal direction. Details of this arrangement are shown in Figs. 8 and 9.

In Fig. 6 typical details are shown of the 100-ft. plate-girder span.

At the western end of the bridge a high cut bank of hard clay had to be crossed, and although this bank was cut down to a slope of 1½ to 1, it was considered inadvisable to place pedestals on this bank, and it therefore became necessary to span this with a deck lattice truss span 167 ft. long. The top chords of this span had to be built of special design in order to carry the heavy erection traveler, which will be referred to later on, and to give the effect of through plate-girders as viewed from the bridge floor; the bottom of these chords being at rail-level while the top is flush with the top flanges of adjacent plate-girder spans.

The tower columns are of very liberal dimensions, the bottom sections being composed of six angles, two web-plates 25 ins. wide, one cover-plate 26 ins. wide, in addition to two 6-in. plates placed in the inside of the columns. Longitudinal and transverse bracing is composed of angles laced together, the diagonal bracing being figured for tension only; struts composed of channels placed back to back and latticed are used to take compression stresses. Long struts are supported in the center.

The use of double triangular type of bracing (without the horizontal struts) was considered, but was not used because of the great length of compression diagonals.

Details are also shown (in Figs. 6 and 9) of the bearing of the spans on column caps, consisting of steel keys set in slots in the cap of the column and riveted to the girder shoe. In the fixed end the key is a neat fit in the groove of the column cap, but in the expansion end the key is made narrow so as to provide clearance on either side for movement of key in the slot. The underside of these keys is beveled at the edges to provide against their binding in the cap-plates. Detail is also shown of the shore end of the flanking spans which shows how the top flanges are curved.

ERECTION.—A material yard was located a short distance east of the eastern end of the bridge, over which was erected a traveling crane, consisting of a standard 125-ft. highway span, provided with end wheels, two of which at each end are connected up by gearing and shafting to standard two-drum hoisting-engine, thus providing for its traveling along the runway. Each end of the crane is provided with a 5-ton 42 ft. boom derrick commanding the additional storage area of 40 ft. wide by the length of the runway for the storage of lighter class of material, the main area between the crane and the runways being utilized for the storage of girders and heavy columns. The length of crane runway is 240 ft., and the height 37½ ft.

For lifting 100-ft. girders, which weigh about 30 tons each, two sets of three-sheave steel blocks rigged with ⅝-in. line were provided, with a capacity of 17 tons each, connected up to a standard double-drum hoisting engine. Turning of the 100-ft. girders end for end is provided for by hooks and beams arranged to swivel on the center floor beam of the 125-ft. crane, such arrangement being desirable in the event of girders reaching the work wrong end first.

For the purpose of transporting material from the storage yard to the front the contractor is provided with constant use of locomotive and ten flat cars.

The main traveler for the erection of this viaduct is a very ponderous machine, built entirely of steel, except

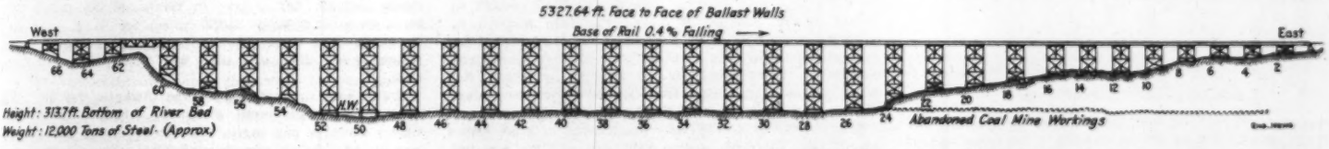
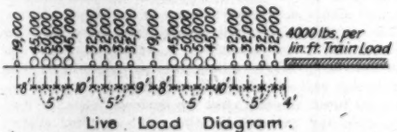

5327.64 ft. Face to Face of Ballast Walls
Base of Rail 0.4% Falling
West
East
Height: 313.7 ft. Bottom of River Bed
Weight: 12,000 Tons of Steel (Approx.)
KW
Abandoned Coal Mine Workings

FIG. 4. OUTLINE ELEVATION OF LETHBRIDGE VIADUCT.

(Tower spans, 67 ft.; Intermediate spans, 98 ft. 10 ins.; Truss span at bank 167 ft.; Height from river bed to rail level, 314 ft.; Highest tower 285 ft. high from top of pier to bottom of girder seat.)



Live Load Diagram.
(C.P.R. Specification for Steel Bridges 1905)

FIG. 5. VIEW ACROSS BELLY RIVER VALLEY DURING CONSTRUCTION OF VIADUCT.
(Work on piers in foreground; Erection of steel in background.)

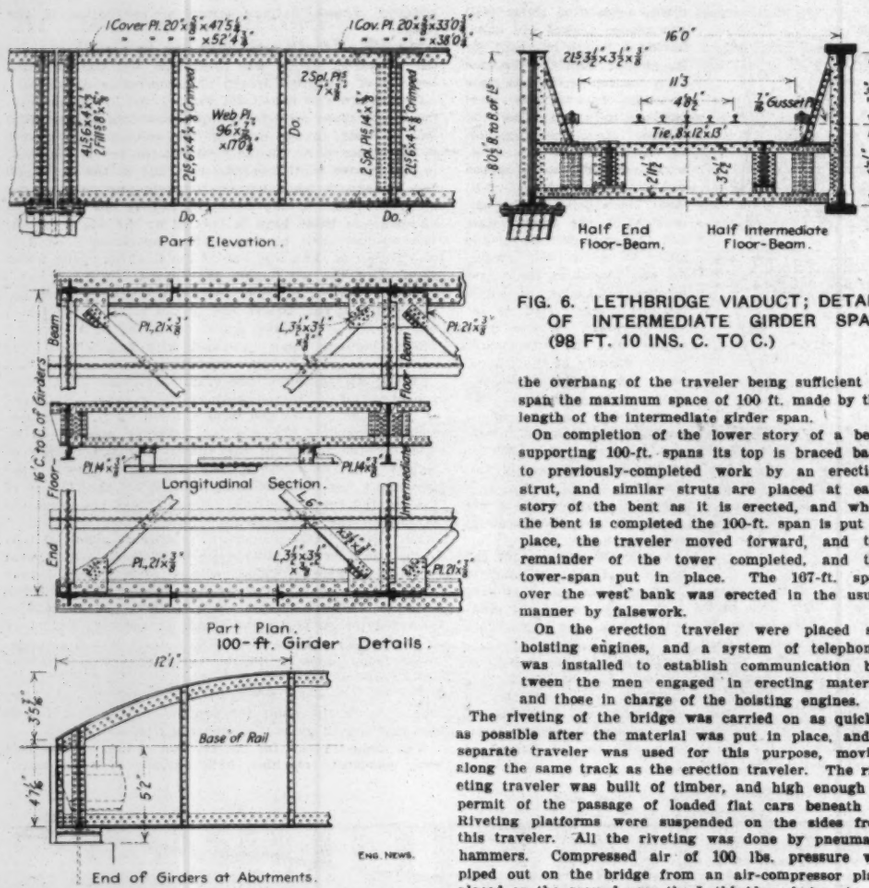


FIG. 6. LETHBRIDGE VIADUCT; DETAIL OF INTERMEDIATE GIRDER SPAN (98 FT. 10 INS. C. TO C.)

with three 24-in. cast-steel wheels, and the forward end is supported on four similar wheels. The rear end of the traveler is counterweighted with 46 tons of steel rails, in addition to the weight of the engine-house, platforms, and hoisting machinery contained thereon. The traveler runs on 80-lb. rails on oak planking along the top flanges of the girders, the rails and oak planking being bolted together in sections, so as to facilitate its placing and removal with each movement of the traveler. The weight of the traveler in working condition is 712,000 lbs. The clearance under the deck of the traveler was made sufficient to permit the running of flat cars loaded with girders under it.

The strains of the traveler were carefully calculated, special attention being paid to the matter of wind stresses on account of the very high winds certain to occur during the time of erection, which was estimated to be one year. The stress sheet was made up on the expectation that it might be necessary to carry the entire weight of the bottom story of the bent suspended from the end of the traveler, which would make a total load of 90,000 lbs. at the end of the traveler. This estimation is due to the expectation of assembling such bottom story flat on the ground and then lifting it vertically into position on the piers. This method was later abandoned in favor of placing each item in the bent directly in its final position. To carry out this latter plan it was found desirable to suspend from the end of the traveler an assembling cage.

The erection traveler is hung with four trolleys hung on two trucks 8 ft. apart center to center, which trucks extend the whole length of the overhang and about two-thirds of the balancing arm. All of the material is taken directly from flat cars run under the rear end of the traveler and handled by these trolleys, each one of which is provided with a 40-ton hydraulic jack of 18-in. stroke, these jacks being used to lift the girders from the cars, as it was undesirable to set the traveler high enough to give head room for block and tackle for this purpose.

The girders were run out on flat cars under the traveler, and when transferred to these trolleys they were pulled forward on to the cantilever-arm of the traveler until in a proper position for lowering into place. Lighter material, such as longitudinal bracing, was lowered direct to the ground by wire-rope tackles, and raised to position in the structure by special 85-ft. swinging booms of 5 tons capacity each, attached to the traveler.

In erecting the bents the traveler is moved to position to bring the hoisting tackle at the end of the traveler directly over the center line of the bent to be erected, the overhang of the traveler being sufficient to span the maximum space of 100 ft. made by the length of the intermediate girder span.

On completion of the lower story of a bent supporting 100-ft. spans its top is braced back to previously-completed work by an erection strut, and similar struts are placed at each story of the bent as it is erected, and when the bent is completed the 100-ft. span is put in place, the traveler moved forward, and the remainder of the tower completed, and the tower-span put in place. The 167-ft. span over the west bank was erected in the usual manner by falsework.

On the erection traveler were placed six hoisting engines, and a system of telephones was installed to establish communication between the men engaged in erecting material and those in charge of the hoisting engines.

The riveting of the bridge was carried on as quickly as possible after the material was put in place, and a separate traveler was used for this purpose, moving along the same track as the erection traveler. The riveting traveler was built of timber, and high enough to permit of the passage of loaded flat cars beneath it. Riveting platforms were suspended on the sides from this traveler. All the riveting was done by pneumatic hammers. Compressed air of 100 lbs. pressure was piped out on the bridge from an air-compressor plant placed on the ground near the Lethbridge abutment.

TIME AND QUANTITIES.—The raising of steel began about Aug. 15, 1908, and a good deal of time was lost during the winter months on account of extremely cold weather, and two weeks in February on account of a strike of the workmen. During the month of March, 1909, bents 37-46 inclusive were completely erected, comprising a tonnage handled during that month of 2,300 tons and about 735 lin. ft. of structure.

A serious accident was averted because of the through-girder construction: A heavy derrick-car handling some heavy material was accidently tipped over, but was restrained from falling by the through girders.

The quantities in the structure are approximately as follows: Dry excavation, 18,110 cu. yds.; wet excavation, 4,870 cu. yds.; concrete, 17,080 cu. yds., concrete piling, 1,676 piles; riprap, 339 cu. yds.; steel, 12,200 tons.

Throughout the work careful records were kept of all measurements, triangulations, and all other work, the note-books being carefully indexed. In addition to this, weather records were kept, together with notes as to the wind, as on many occasions the wind was so strong that the men could not work on the erection of the bridge. In addition to this, records were kept showing progress of work in accordance with form, which is attached. These were sent into the head office twice a month in order that a check might be kept on the progress of the work. Attached are several photographs showing wooden trestles and bridges on the old line, and several photographs showing the pedestals, the river piers, and the steel work of the new bridge.

During high water a new channel was formed about 300 ft. east of the old one, and considerable gravel was carried down and deposited in the vicinity of the bridge. This is shown on the contour map.

The bridge was designed by the bridge department of the Canadian Pacific Railway at Montreal, [illegible] the field work was carried out under the direction [illegible] the assistant chief engineer, Western Lines, Winnipeg.

The manufacture, designing of erection equipment and erection of the steel-work were carried out in a most efficient manner by the Canadian Bridge Co., of Walkerville, Ontario, contractors for superstructure. [illegible] F. Prettie had direct charge for the bridge company in the field, and had a gang of about 100 men.

[Mr. Schwitzer's paper also described the notable grade reduction in the Kicking Horse Valley in British Columbia between Hector and Field, where a 4.5% grade 4 miles long was abolished by developing a 2.2% grade through a loop involving two spiral tunnels on 10° curve. This work was described in our issue of Jan. 23, 1908, p. 87, with a map of the new location and some views. During the two seasons since then, the work has been prosecuted to completion, and the new line was opened to traffic on Aug. 24, 1909.—Ed.]

Recent Progress in Ocean Transportation and Ship Propulsion.*

By SIR WM. H. WHITE.

Since the introduction of iron for the structures of ships and of steam as the propelling power marvellous economies have been effected in the cost of over-sea transport. The chief causes contributing to this result have been (1) improvements in steam machinery, leading to great reductions in coal consumption, (2) considerable enlargement in the dimensions of ships, and (3) the supersession of iron by steel for structures and machinery.

Rates of freight, of course, vary greatly as the conditions of trade and the stress of competition change. At the present time these conditions remain unfavorable, although it may be hoped that there are signs of improvement, after long and severe depression. It will be preferable, therefore, to give facts for more normal circumstances, such as prevailed five or six years ago. Coal was then carried from the Tyne to London (315 miles) for 3s. 3d. a ton; to Genoa (2,388 miles) for 5s. a ton; to Bombay (6,358 miles) for 8s. 6 d. a ton, including Suez Canal dues. The corresponding rates of freight were .111, .025, and .016 of a penny per ton-mile.

Grain was brought across the Atlantic for 9d. per quarter in large cargo steamers, whereas in former times, when it was carried in small vessels, the charge was 9s. 6d. Goods were carried 6,400 miles eastward via the Suez Canal in tramp steamers at an inclusive charge of 25s. to 30s. a ton, the freight rate averaging about .05 of a penny per ton-mile. It was estimated at that time that the average railway rate per ton-mile in Great Britain for cost of transport and delivery of goods was about 30 times as great; but the moderate distances traveled, local and national taxation, high terminal charges, and the immense outlay involved in the construction, equipment, and maintenance of railways account for much of the great difference in cost of transport. The ocean furnishes a free highway for the commerce of the world.

Economy of fuel-consumption has played a great part in the reduction of working expenses in steamships. Fifty years ago from 4 to 5 lbs. of coal per indicated HP. represented good practice in marine engineering for

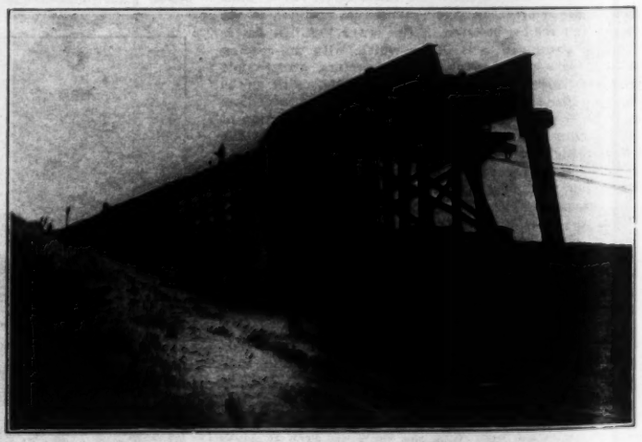


FIG. 7. END SPAN OF LETHBRIDGE VIADUCT IN PLACE.
(The top flange is curved down toward rail level for the sake of appearance.)

*Extract from the Presidential Address before the British Association for the Advancement of Science at the Winnipeg meeting.

screw steamships. At present, with quadruple expansion engines, high-steam pressures, and more efficient reciprocating engines from 1¼ to 1½ lbs. is common practice and better results are claimed in some cases. A coal steamer of the tramp type, carrying 6,500 tons dead weight, can cover about 265 knots in 24 hours in fair weather for a coal consumption of 27 tons per day, representing an expenditure on fuel of 20£ to 25£. A larger vessel carrying about 12,000 tons dead-weight, driven by engines of similar type, would consume about 45 tons in covering the same distance at the same speed. This increased economy in fuel per ton-mile is the result of an increase in dimensions from 365 ft. length, 47-ft. breadth, and 24½-ft. draft of water to a length of 450 ft., a breadth of 56 ft., and a draft of 27½ ft.

The first cost of cargo steamers is small in relation to their carrying capacity and possible earnings; varying, of course, with the current demand for new steamships. In the present depressed condition of shipping, about 5£ 10s. per ton dead-weight is named as a current rate; in busy times the price may be 40 to 45% higher; even then it is small in proportion to earning power. Working expenses are kept down also by the use of efficient appliances for rapidly shipping or discharging cargoes, and so shortening the stay of ships in port. As an example, a case may be mentioned when a ship of 12,000 tons dead-weight and 800,000 cu. ft. measurement capacity had her full cargo discharged at an average rate of 300 tons an hour, a fresh cargo put on board at the rate of 250 tons an hour, and 1,600 tons of coal shipped between 7 a. m. on Monday and noon on the following Friday—that is, in 101 hours. In another case a cargo weighing 11,000 tons was discharged in 66 hours. "Quick dispatch" in dealing with cargo is now universally recognized as essential, and it has been asserted that a saving of one day in discharging or loading a tramp steamer when she finds full employment may involve an expense equal to 1% on her first cost.

The "intermediate" type of steamer—in which large carrying capacity is combined with provision for a considerable number of passengers and moderate speed—is of comparatively recent date, but it has been developed rapidly and is subject to the universal laws to which all classes of shipping conform. Increase of size is adopted in order to favor economy in working and greater earning power, while increase in speed is made in some cases. Vessels like the "Adriatic" or "Baltic" of the White Star Line, the "Carmania" and "Caronia" of the Cunard Line, and the "George Washington" of the Hamburg-American Line illustrate this statement; while its latest and greatest examples are found in the two steamers now building for the White Star Line by Messrs. Harland and Wolff, which are said to be of 45,000 tons, to be intended to steam 20 to 21 knots, to provide accommodation for a great number of passengers, and to have large capacity for cargoes.

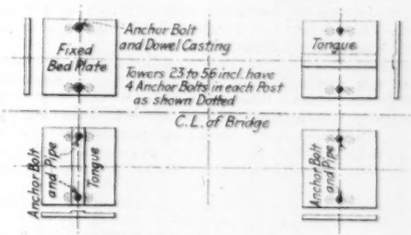
In mail and passenger steamers of the highest speed, increase in dimensions is devoted chiefly to provision for more powerful propelling apparatus and for a correspondingly large quantity of fuel, and the cargo-carrying capacity is relatively small; but the law of increase in size and cost is obeyed, and will be followed up to the limit which may be fixed by the vast outlay necessary in order to provide suitable harbors and dock accommodation with an adequate depth of water, or by commercial considerations and the possibility of securing a suitable return on the large capital expenditure. Growth in dimensions of ships will not be determined by the naval architect and marine engineer finding it impossible to go further, for there are even now in view possibilities of further progress if the shipowner so desires. Invention and improvement have not reached their ultimate limits.

The wonderful progress made during the last 70 years is well illustrated by the history of shipping trading between Canada and Great Britain, and it may be of interest to recall a few of the principal facts. For a long period, trade and communications were carried on by wood-built sailing ships, many of the finest being Canadian built; but at a very early period Canadians had under consideration the use of steamships. One of the first steamers to cross the Atlantic was the "Royal William" paddle-steamer, built near Quebec in 1831. She was 160 ft. long, 44 ft. broad, of 363 tons burden, sailed from Quebec on Aug. 5, 1833, and reached Gravesend on Sept. 16, a passage of more than 40 days, in the course of which sail-power was largely used. Cabot, in 1497, crossed in the good ship "Matthew," of 200 tons burden, which was probably from 90 to 100 ft. in length; so that three centuries of progress had not made very great changes in size of the ships employed. Wood was still the material of construction, and sails were still used as a motive power, although the steam-engine was installed. In 1839 it was a Canadian, Samuel Cunard, who secured—in association with two British shipowners, Burns and McIver—the contract for a monthly Trans-atlantic service from Liverpool to Halifax and Boston. The four steamers built were wood-hulled, driven by paddle-wheels, had good sail-power, and were of the following dimensions: 207 ft. long, 34½ ft. broad, 1,150 tons burden, and about eight knots speed. A rapid passage to Boston then occupied about 14 days.

Another Canadian enterprise, the Allan Line, started about 56 years ago. The Allan Line was amongst the first to use steel instead of iron for hulls, and in their two largest steamers now in service, dating from 1903, they were the first to adopt steam turbines for ocean-going ships, although their lead over the Cunard Company was not long. The "Virginian" and "Victorian" are 520 ft. long, 60 ft. broad, of 10,750 tons, and their maximum speed is 18 knots.

The latest addition to the Canadian service has been made by the White Star Line in the form of two steamers, the "Laurentic" and "Megantic," of 15,000 tons, 550 ft. long, about 67 ft. broad, and 17 knots speed. In the "Laurentic" an interesting experiment has been made—Messrs. Harland & Wolff having introduced a combination of reciprocating engines and a low-pressure turbine. This system was patented as long ago as 1894 by Mr. Charles Parsons, to whom the invention of the modern steam turbine and its application to marine propulsion are due. Mr. Parsons foresaw that while the turbine system would prove superior to reciprocating engines in ships of high speed and with a high rate of revolution, there would be a possibility of getting better results by combining reciprocating engines with low-pressure turbines in ships of comparatively slow speed, where a low rate of revolution for the screw-propellers was necessary to efficient propulsion.

His main object, as set forth fifteen years ago, was "to increase the power obtainable by the expansion of the steam beyond the limits possible with reciprocating engines," and subsequent investigations led Mr. Parsons to the conclusion that it would be possible by using the combination system to secure an economy of 15 to 20% more than that obtainable with efficient types of reciprocating engines. Many alternative arrangements have been designed for combining reciprocating engines


Anchor Bolt and Dowel Casting
Fixed Bed Plate
Towers 23 to 56 incl. have 4 Anchor Bolts in each Post as shown Dotted
C.L. of Bridge
Tongue
Anchor Bolt and Pipe

Expansion Diagram for Towers.

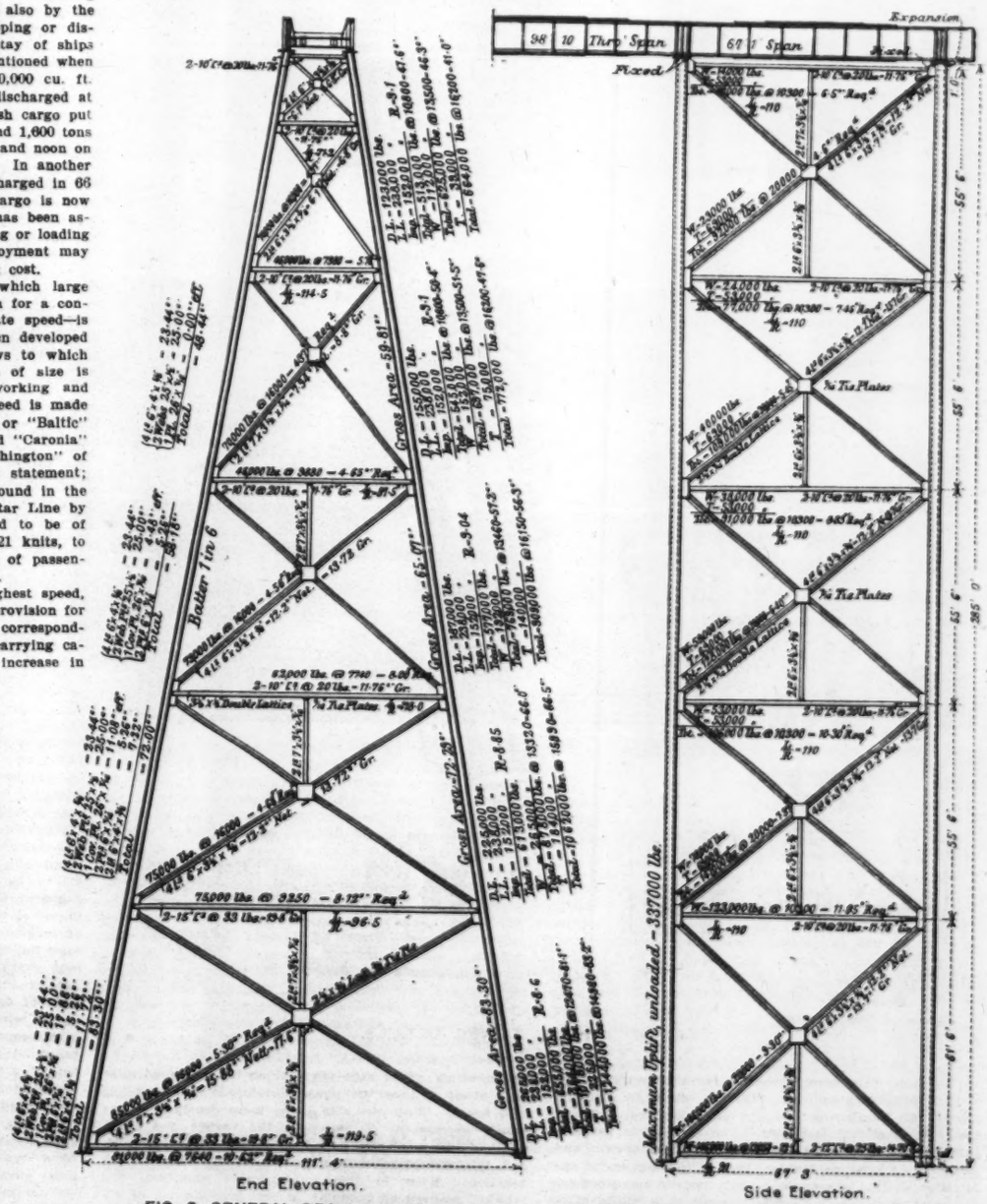


FIG. 8. GENERAL DRAWING OF 285-FT. TOWER OF LETHBRIDGE VIADUCT.

with low-pressure turbines; that now under trial associates twin-screw reciprocating engines, in which the expansion of the steam is carried down to a pressure of 9 to 10 lbs. per sq. in. when working at maximum power, and then completed to the condenser pressure in a turbine. Triple screws are employed, the central screw—driven by the turbine—running at a higher rate of revolution than the side screws, which are driven by the reciprocating engines.

The "Laurentic" has been but a short time in service, and few particulars are available of her performances as compared with those of her sister ship, fitted with reciprocating engines. It has, however, been reported that the results have proved so satisfactory that the combination system will probably be adopted in the two large White Star steamers of 45,000 tons now building

Her installation of boilers is identical with that of her sister ship, the reciprocating-engined twin-screw steamer "Orari," which is 4 ft. 6 ins. shorter than the "Otaki," but generally of the same form. On the measured mile the "Otaki" obtained a speed of 15 knots, while the "Orari" reached 14.6 knots. In order to drive the "Orari" at 15 knots about 12% more horse-power would have been required, and this is a practical measure of the superiority of the combination system over the reciprocating twin-screw arrangement in the "Orari." The total water consumption per hour of the "Otaki" at 15 knots was 6% less than that of the "Orari" at 14.6 knots. If the "Otaki" also ran at 14.6 knots, the water consumption would have been 17% less than that of the "Orari" at the same speed. On the voyage from Liverpool to New Zealand the "Otaki" averaged about 11

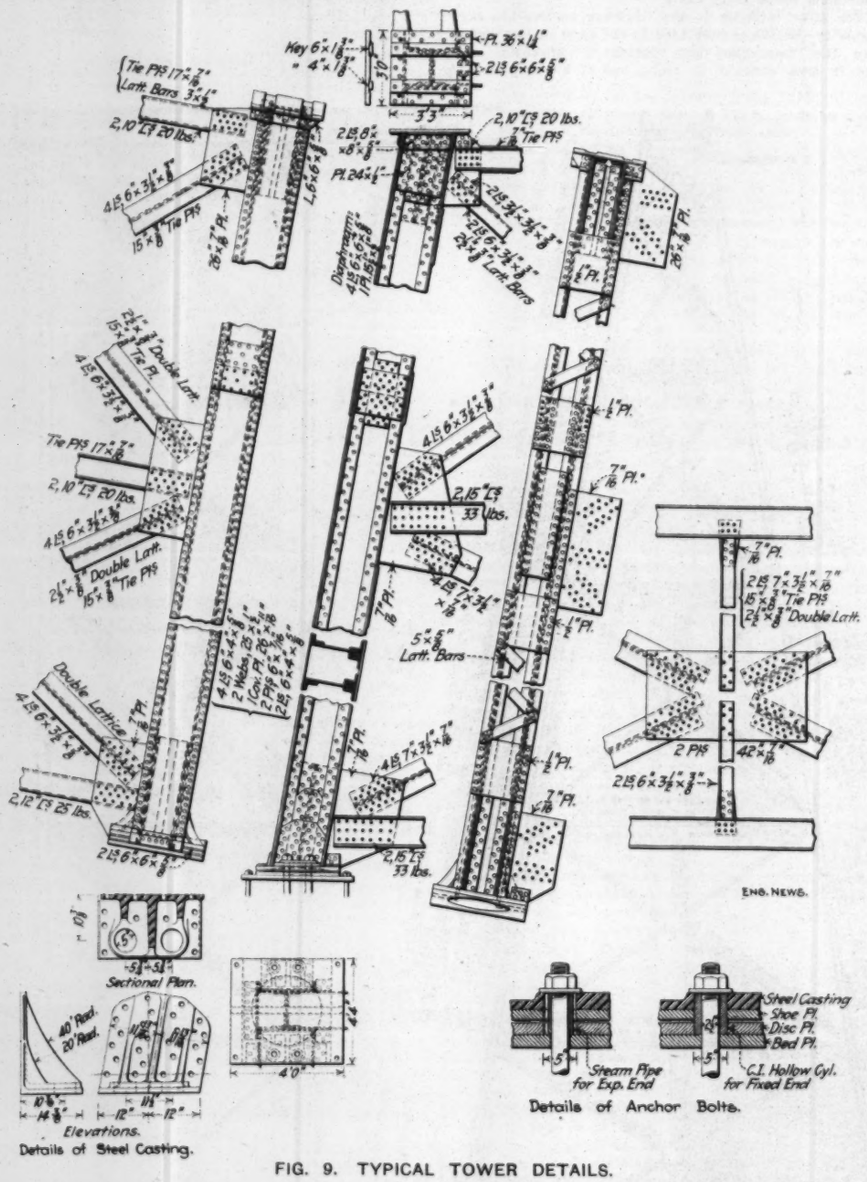


FIG. 9. TYPICAL TOWER DETAILS.

at Belfast. This favorable view is fully confirmed by the performances of the "Otaki," built by Messrs. Denny, of Dumbarton, for the New Zealand Shipping Co., and completed last year. The "Otaki" is the first completed ship fitted with the combination system and subjected to trial on service, and as the successful application of that system to cargo steamers and steamers of the intermediate type would result in a considerable economy in the cost of oversea transport, it may be of interest to give some details of her recorded performance. She is 465 ft. long, about 60 ft. broad, and of 7,420 tons (gross). Her dead-weight capability is about 9,000 tons on a draft of 27 ft. 6 ins., and the corresponding displacement (total weight) is 16,500 tons. The vessel was designed for a continuous sea-speed of 12 knots when fully laden, and the contract provided for a trial speed of 14 knots with 5,000 tons of dead-weight on board. The trials were accordingly made at a displacement of about 11,700 tons.

knots, which would have required on the measured mile only about 40% of the power developed when running 14.6 knots. With the ship laden more deeply, the average development of power on the voyage was about one-half the maximum developed on the measured mile, and this was disadvantageous to economy in the combination. Even in these unfavorable conditions the "Otaki" realized an economy in coal consumption of 8% on the voyage from Liverpool to New Zealand and back as compared with her reciprocating-engined sister ship; this represents a saving of about 500 tons of coal. Ordinarily the ship would leave England with sufficient coal on board for the outward passage, so that 250 tons less coal need be carried and a corresponding addition could be made to cargo and freight-earning.

In designing turbine machinery for vessels of moderate vessel speed there must necessarily be conflicting claims. For maximum efficiency in steam turbines a high rate of revolution is necessary; whereas at moderate or low speeds it is antagonistic to pro[illegible]r efficiency to run at this high rate of revolution. [illegible]ineers are at present much occupied with the st[illegible] of arrangements by means of which these conflic[illegible] claims may be harmonized and greater total efficien[illegible] of propulsion obtained. Having regard to the eno[illegible]s capital invested in cargo steamers of moderate [illegible]k and the importance attaching to their economic [illegible]ng as influencing the cost of oversea transport, it [illegible]e obvious that it is most desirable to find an ar[illegible]ement in which the high speed of the rotor may be r[illegible]ed by means of some form of gearing, or its equival[illegible] so as to enable the screw shaft and its propeller to [illegible] run at a speed which will secure maximum propeller [illegible]ency. Many proposals have been made, including m[illegible]anical gearing and hydraulic or electric apparatus fo[illegible] transforming the rate of motion. Some of these are [illegible]ctually undergoing experimental trials, and are said [illegible] have given very promising results.

One of the most important trials is that undertaken by the Parsons Marine Steam Turbine Co., which has purchased a typical tramp steamer, and is carrying out on her a series of trials in order first to ascertain accurately what are the actual conditions of steam and coal consumption with the present reciprocating engines, and then to ascertain the corresponding facts when those engines have been removed and a steam turbine with its associated gearing has been fitted.

It is interesting to note in passing that in the earliest days of screw propulsion with slow-running engines it was found necessary to adopt gearing in order to increase the rate of revolution of the propellers, whereas at present interest is centered in the converse operation. Furthermore, if any system of gearing-down proves successful it may be anticipated that its application will be extended to swift turbine-driven steamships, since it would enable good propulsive efficiency to be secured in association with rapidly running turbines of smaller size and less weight than have been employed hitherto.

The Marine Steam Turbine.

The rapid development of the marine steam turbine during the last seven years constitutes one of the romances of engineering, and the magnitude of the work done and the revolution initiated by Mr. Charles Parsons will be more justly appreciated hereafter than it can be at present. In some quarters there is a tendency to deal critically with details and to disregard broader views of the situation as it stands to-day. In May, 1909, there were 273 vessels built and under construction in which steam turbines of the Parsons type are employed, the total horse-power being more than three and a half millions. In the Royal Navy every new warship, from the torpedo-boats up to the largest battleships and armored cruisers, is fitted with turbine engines; and the performances of vessels which have been tested on service have been completely satisfactory, in many instances surpassing all records for powers developed and speeds attained. In the war fleets of the world this example is being imitated, although in some cases it was at first criticised or condemned.

In the mercantile marine as a whole, while the new system has not made equal advance, many notable examples can be found of what can be accomplished by its adoption. It is now admitted that steam turbines enable higher speeds to be attained in vessels of given dimensions; and in steamers built for cross-channel and special services, where high speed is essential and coal consumption relatively unimportant, turbines have already ousted reciprocating engines.

For oversea service and long voyages an impression has existed that the coal consumption of turbine-engined ships would considerably exceed that of ships driven by triple or quadruple expansion reciprocating engines. Critics have dwelt on the reticence in regard to actual rates of coal consumption practised by owners of turbine steamships. Naturally there are other reasons for reticence than those which would arise if the coal consumption were excessive; but pioneers in the use of turbine machinery may reasonably claim the right of non-publication of results of trials in the making of which they have incurred large expenditure and taken considerable risks if they think that silence is beneficial to their business interests. Even if it were true that in the earliest applications of the new system economic results had not been obtained equal to those realized in reciprocating engines which have been gradually improved during half a century, that circumstance should not be regarded as a bar to acceptance of a type of engine that admittedly possesses very great advantages in other ways, but should be regarded as an incentive to improvements that would secure greater economy of coal.

The evidence available, however, does not confirm the adverse view, and those familiar with the facts do not admit its truth. One example may be cited as it affects the Canadian service. In June, 1907, it was authoritatively stated that in the Allan liner "Virginian" the reports which had been circulated respecting the excessive coal consumption were unfounded, that the ve[illegible] was making passages at speeds of 17½ to 17¾ knots, as against the 17 knots estimated, and the rate of coal consumption was really about 1.4 lbs. per indicated HP.

which would have been required to attain this speed if the vessel had been fitted with reciprocating engines. This result compares well with the consumption in ordinary passenger steamers running at high speeds in proportion to their dimensions, although in large cargo steamers and vessels of the intermediate type, working under much easier conditions and at very low speeds in proportion to dimensions, lower rate of consumption may be obtained. With these latter vessels the fair comparison is the combination system and not the pure turbine type which is adapted for high speeds.

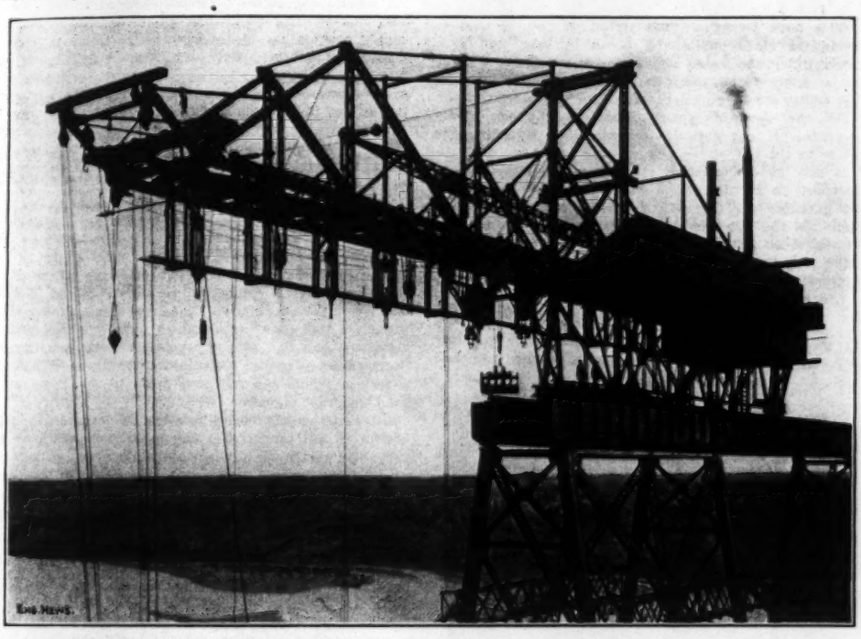
The crowning triumph of the marine steam turbine up to the present time is to be found in the great Cunard steamships "Lusitania" and "Mauretania." The passages made this year by the latter ship since she was refitted have been marvellously regular, and the 25 knots average across the Atlantic, which was the maximum contemplated in the agreement between the Government and the Cunard Company, has been continuously exceeded. As one intimately concerned with the design of the "Muretania," who has had large experience in ship design, has made a life-long study of the laws of steamship performance, and had the honor of serving on the committee which recommended the employment of turbines in these great ships, the writer ventures to assert that equal results could not possibly have been obtained with reciprocating engines in vessels of the same form and dimensions. Contrary opinions have been expressed, but they have been either based upon incorrect data or have omitted consideration of the fact that in vessels of such great engine-power it was necessary to have time to perfect the organization of the staff in order to secure uniform conditions of stoking and steam production, and to bring the "human element" into a condition which would ensure the highest degree of efficiency in working the propelling apparatus.

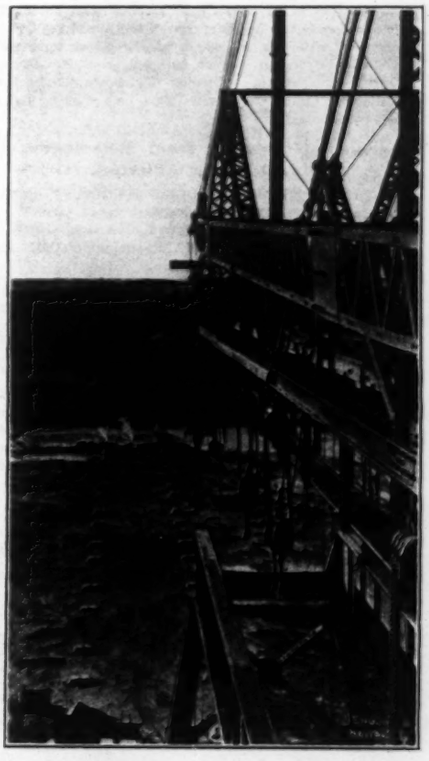
This necessity for time and training has been illustrated again and again in the case of new types of Trans-atlantic steamers, including some which held the record for speed prior to the appearance of the Cunarders. In the "Lusitania" and "Mauretania" the engine-power is fully 60% greater than that of their swiftest predecessors, yet no similar allowance appears to have been thought necessary by some critics, who assumed that performances on the earlier voyages represented the maximum capabilities of the vessels. Subsequent events have shown this view to be fallacious and have justified the recommendation of the Turbine Committee and the action of the Cunard directors. Allegations made in regard to excessive coal consumption have also been disproved by experience; and in this respect the anticipations of the committee and of Mr. Parsons have been fully realized.

The marvellous regularity maintained by the "Mauretania" on a long sequence of consecutive Trans-atlantic passages—made under varying and in many cases very adverse conditions of wind, weather, and sea—illustrates once more, and on an unprecedented scale, the influence which large dimensions have upon the power of maintaining speed at sea. Starting from the eastward passage, beginning on Feb. 3 last, and taking twelve passages (westward and eastward) which followed, the average speed for the thirteen passages, approaching 40,000 sea-miles in length, has been 25½ knots; the lowest average speed in the series has been 25.2 knots, the highest average speed 25.88 knots. Many of the winter passages in this series were made in winter weather against strong winds and high seas, which would have considerably reduced the speed of her predecessors, but had small influence on the "Mauretania." In many instances delays have been caused by fogs.

On seven consecutive passages made since the beginning of last May the average speed of the "Mauretania" in covering about 20,000 sea-miles has been 25.68 knots, the minimum speed for the passage having been 25.62 knots and the maximum 25.88 knots. On her contract trials, the "Mauretania" maintained an average speed of 26.04 knots for a distance somewhat exceeding 1,200 knots, the steaming time being rather less than 48 hours. On the passage when she averaged 25.88 knots, she ran 1,215 knots from noon on June 17 to noon on June 19 (about 46 hours), at an average speed of 26.23 knots, and by noon on the 20th had covered 1,817 knots at an average speed of 26.18 knots for 69 hours. The ship has, therefore, surpassed on service her performance on the contract trial.

In view of the foregoing facts and of others of a similar nature, it is reasonable to assume that as experience is enlarged and information is accumulated in regard to forms of propellers likely to prove most efficient in association with quick-running turbines, sensibly improved performances will be obtained. At present, in comparisons made between the efficiency of reciprocating-engined ships and turbine-engined ships, the former have the great advantage attaching to long use and extended experiment; but this is not a permanent advantage, and it may be expected that good as the position is to which the marine steam turbine has attained in the brief period it has been in practical use, that position will be gradually improved. Whether or not other forms of propelling apparatus in their turn will surpass the steam turbine it would be unwise to predict. Internal combustion engines are regarded in some quarters as dangerous and probably successful rivals to steam turbines in the near future. Within certain limits of size, internal combustion engines no doubt answer admirably; but as dimensions and individual power of the engines are increased, the difficulties to be overcome also rapidly increase, and the fact is fully recognized by those having the best knowledge of those types of prime movers. On the whole, therefore, it seems probable that the turbine will not soon be displaced, whatever may happen eventually.





FIGS. 10 AND 11. TWO VIEWS OF THE TRAVELER AT WORK, LETHBRIDGE VIADUCT.

List of Analyses and Methods of Testing Bituminous Materials for Road Construction.*

Tars.

WATER-SOLUBLE MATERIALS.—Boil gently two grams of material with 25 c.c. of distilled water for one hour. Filter and wash with 25 c.c. of boiling water. Evaporate filtrate in weighed dish to dryness and constant weight at 105° C. Weigh residue. Ignite residue and weigh again, giving weight of inorganic matter plus weight of crucible. Weight No. 2 minus weight No. 3 gives weight of organic matter.

SPECIFIC GRAVITY.—Use some standard form of pyknometer. Material and distilled water must have a temperature of 25° C. For semi-solid and solid materials use Sommer's Pyknometer.

FREE CARBON.—The free carbon shall be determined by dissolving for 15 hours, 2 grams of the compound in 100 c.c. of cold carbon bisulphide, filtering the solution through a weighed Gooch crucible, fitted with an asbestos pad, drying to constant weight, and weighing the insoluble residue; then igniting crucible until all carbon is burned off, weighing the residue (ash). The difference between the 2d and 3d weights is "free carbon."

FIXED CARBON.—About one gram of the compound is weighed into a platinum crucible 1⅛ to 1½ ins. high. The crucible with the lid on is heated, first gently, and then until no more smoke and flame issues between the crucible and the lid. It is then heated 3½ minutes in the full heat of the burner; then cooled and weighed. The crucible lid is then removed and the crucible and contents allowed to remain in the full heat of the burner until the carbon is burned off, and then weighed again. The difference between these two weights is the fixed carbon.

EVAPORATION.—20 grams of compound are heated in a flat-bottomed dish, 2½ ins. in diameter and about 1 in. high, for a total of 5 hrs. in three successive periods of 3, 1 and 1 hrs., respectively, in an oven, the interior of which is maintained at a uniform and constant temperature of 170° C. This oven is to be controlled by any thermoregulator controlling within two degrees, and is to have its full temperature before the compound is introduced. The dish must be level. Remove dish from oven and stir contents thoroughly for one minute between successive periods.

PENETRATION OF RESIDUE FROM EVAPORATION TEST.—The penetration shall be measured by a standard machine using 100 grams load and No. 2 needle. Use a flat-bottomed glass dish ⅞-in. in diameter and 1½ ins. in height. Fill flush with top with material and allow same to stand at room temperature for one-half hour. Immerse in water bath, covering material for 1 hr. Immerse needle to be used for five minutes in same bath. Test at once, making three determinations. The recorded penetration shall be the average value. Temperature 4° C. and 25° C.

(Note): Residue must be melted at lowest possible temperature and thoroughly mixed by stirring.

MELTING POINT OF RESIDUE FROM EVAPORATION.—The material whose melting point is to be determined, is melted and poured into a mold that will make a ½-in. cube. A No. 10 gage wire about 6 to 8 ins. long is bent at right angles for a length of ¾-in. at one end and the center of the cube is placed on this end so that one of the diagonals of the vertical face of the cube is parallel to the long part of the wire. Take a bottle of a size about 2 ins. in diameter and 4 ins. high and

*Proposed by a Special Committee on Bituminous Materials for Road Construction, American Society of Civil Engineers. Mr. A. H. Blanchard, East Side Station, Providence, R. I., is Secretary of the committee. Brief editorial comment on this subject may be found elsewhere in this issue.

place a piece of white paper in the bottom of it. Pass the long part of the wire through the cork of the bottle so that the lower edge of the cube will be within 1 in. of the bottom of the bottle. Also put a thermometer through the cork so that the bulb is opposite the cube. Place the bottle in a water or oil bath and raise the temperature of the bath at a rate of 3 to 6° C. a minute. The melting point of the material is the temperature of the thermometer inside the bottle at the time that the material touches the paper in the bottom of the bottle.

DISTILLATION.—Up to 105° C. From 105° to 170° C. From 170° to 225° C. From 225° to 270° C. From 270° to 300° C.

Seven hundred grams of the compound are weighed into a retort (E. & A. four pints No. 4521), whose top is fitted with a tee as close as possible to the retort, and a condenser pipe 24 to 36 ins. long; the upper branch of the tee is used for the insertion of a thermometer, the top of whose bulb is placed immediately below the main outlet of the tee.

VISCOSITY OR CONSISTENCY.—Temperatures at which viscosities will be determined, are 100° C. and 25° C.

Penetrometer to be used in accordance with standard method on materials solid at above temperatures. The viscosity of materials, on which at the above temperature the penetrometer cannot be used, shall be determined by one of the following instruments: Engler Viscosimeter; Lunge Tar Tester; New York Testing Laboratory Viscosimeter.

Compounds Prepared from Petroleum or Natural Asphalt Pitches.

MELTING POINT OF SOLID ASPHALTS.—Same method as for residue from evaporation of tars.

FREE CARBON.—Same method as for tars.

WATER-SOLUBLE MATERIALS.—Same method as for tars.

SPECIFIC GRAVITY.—Same method as for tars.

FREE CARBON.—Same method as for tars.

MATERIAL SOLUBLE IN COLD CARBON-TETRACHLORIDE.—Same method as for free carbon, except carbon-tetrachloride is used as a solvent instead of carbon-bisulphide.

FIXED CARBON.—Same method as for tars.

PARAFFINE.—100 grams or less of the compound is distilled rapidly in a retort to dry coke.

Five grams of the well mixed distillate is treated in a 2-oz. flask with 25 c.c. Squibbs absolute ether; after mixing thoroughly, 25 c.c. Squibbs absolute alcohol is added and the flask packed closely in a freezing mixture of finely crushed ice and salt for at least 30 minutes. Filter the precipitate quickly by means of a suction pump, using a No. 575 C. S. & S. 9-c.m. hardened filter paper. Rinse and wash the flask and precipitate (with 1 to 1 Squibbs alcohol and ether mixture cooled to —17° C.) until free from oil (50 c.c. of washing solution is usually sufficient.) When sucked dry remove paper, transfer waxy precipitate to small glass dish, evaporate on steam bath and weigh paraffine remaining on dish.

CALCULATION. — Weight of paraffine divided by weight of distillate taken and multiplied by per cent. of total distillate used from original sample, equals per cent. of paraffine.

EVAPORATION TEST NO. 1.—Same method as for tars.

PENETRATION OF RESIDUE FROM EVAPORATION TEST NO. 1.—Same method as for similar residue of tars.

MELTING POINT OF RESIDUE FROM EVAPORATION TEST NO. 1.—Same method as for similar residue of tars.

SOLUBILITY IN 88° BAUME NAPHTHA.—Two grams of compound are placed in 4-oz. oil sample bottle made up to 100 c.c. with 88° B. naphtha, having a boiling point between 40° C. and 55° C., the whole well shaken until compound is broken up. The bottle is then centrifugalized for 10 minutes, 50 c.c. are withdrawn into a weighed flask, the naphtha distilled by a water bath and the residue weighed. Another 10 c.c. of the naphtha solution is run over 3½ ins. Petri glass and allowed to evaporate for 24 hours at room temperature. Note character of residue, i. e., sticky or oily.

VISCOSITY OR CONSISTENCY.—Same as for tars.

EVAPORATION TEST NO. 2.—Same method as for tars except oven temperature shall be 205° C.

PENETRATION OF RESIDUE FROM EVAPORATION TEST NO. 2.—Same method as for tars.

MELTING POINT OF RESIDUE FROM EVAPORATION TEST NO. 2.—Same method as for tars.

A Suggested Change in Semaphore Signals.*

By C. H. MORRISON.†

As English railways operate their trains to the left of the direction of traffic, they placed their signals on the left on the track and extended the semaphore arm to the left of the signal pole. As the arm moved in the lower quadrant it would probably have interfered with the car clearance had it been placed on the right of the pole. American railways operate their trains to the right, and place the signal to the right of the track governed, with the semaphore arm extending to the right. Why should the arm not extend to the left of the pole and move in the upper quadrant?

Many signal engineers have found it difficult to place signals where they can be plainly seen when the right of way is narrow and the telegraph pole line is close to the tracks without either raising or lowering the wires, and even then the view is often obscured by cross-arms and poles. In cities it has been found necessary to increase tracks until the signals have been crowding over against buildings, and it has been necessary to erect off-set poles to bring the signal out from the buildings.

In this day of low-grade lines and elimination of grade-crossings, often long and deep cuts are made either through rock or with long retaining walls, making it very difficult to locate signals through the cut without the use of off-set poles.

A dark background often obscures the view of the signal to such an extent that an off-set pole is used to bring the blade out where it can be seen, and it is often difficult to locate a signal on the inside of a curve on account of the short chord obtained for a view of the signal arm.

All the above-mentioned difficulties can be greatly benefited, if not entirely overcome, by extending the blade to the left of the pole.

It may be claimed that the semaphore with the arm extended to the left when in the stop position, might be mistaken for the rear side of a signal of the old type for the opposite direction. But on the majority of roads the signal blades are painted so as to distinguish the front from the back and therefore a careful engineman ought not to make the mistake.

The benefits obtained by extending the signal arm to the left are certainly deserving of consideration.

[In the accompanying cut we have shown diagrammatically the three arrangements mentioned. Fig. 1 shows the general arrangement now used, with the arm on the right-hand side of the post and moving in the lower quadrant. Fig. 2 shows the method recommended by the Railway Signal Association (and already in use on some railways), with the arm moving in the upper right-hand quadrant. Fig. 3 shows the change proposed by Mr. Morrison, with the arm on the left-hand side of the post and moving in the upper left-hand quadrant. The arrangement of lamps and spectacle castings is not shown, and would vary for two-position and three-position signals or other conditions. We have commented on this matter in another column.—Ed.]

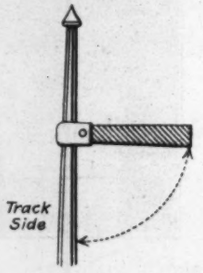


Fig. 1. Lower Right-Hand Quadrant.

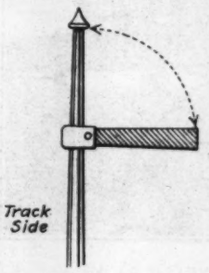


Fig. 2. Upper Right-Hand Quadrant.

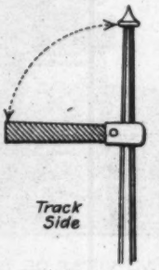


Fig. 3. Upper Left-Hand Quadrant.

DIAGRAM SHOWING MOVEMENTS OF SEMAPHORE ARMS UNDER DIFFERENT SYSTEMS.

Discussion.

Mr. Elliott (New York Central Lines).—I believe the upper left-hand quadrant is the better arrangement, but is it easy to make the change? While the roads that have adopted the upper right-hand quadrant are a minority, some important lines have adopted the system and it would be a great expense to them [illegible] ke the change.

Mr. Yocum (Philadelphia & Reading Ry. [illegible] re the right-of-way is limited and where they [illegible] uilding additional tracks to take up all the righ[illegible], the signal as proposed would be preferable an[illegible] give a better view.

Mr. Rudd (Pennsylvania Ry.).—The left-ha[illegible] drant was given serious thought by the committe[illegible] I felt that it had decided advantages. In part [illegible] trial installation of upper-quadrant work we erec[illegible] signal bridges to avoid telegraph poles, and becau[illegible] we did not have right-of-way to move the telegraph [illegible] back. Some of those bridges would have been save[illegible] using the left-hand quadrant. But the main reaso[illegible] were afraid to recommend it was that the back of [illegible] signal might be taken for the proceed signal on [illegible] other track.

Mr. Sperry (Union Switch & Signal Co.).—T[illegible] signal across the track is undoubtedly logical, and I t[illegible]k Mr. Morrison is right in his position. In the early days of signaling in this country one important line (the Boston & Albany Ry.) used left-hand signals.

Mr. Waldron (Interborough Rapid Transit Ry.).—About 17 years ago, I was installing signals on a road where there were a few signals with the blades to the left of the pole. Enginemen obeyed these signals. In another case there was not room for a signal blade of sufficient length, either to the left or to the right of the signal pole, so the blade was pivoted in the middle. The men running trains had no trouble, they observed simply whether the blades were horizontal or inclined.

Mr. Eck (Southern Ry.).—The blade extending to the left may interfere with car clearance, especially on electric roads. It is becoming more and more the practice to get the signals down to the level of the eye of the motorman, and the placing of the blade in the upper left-hand quadrant would seriously interfere with this. It would be entirely impracticable in many locations, especially on elevated structures.

Mr. Rhea (Pennsylvania Lines).—The committee which recommended the upper-quadrant did not recommend the left-hand side because of the question whether the change must be made as a whole (on sections or divisions) or whether it could be made in renewals. I considered that it could be done only in the former manner. It is doubtful if it can be done satisfactorily without a transition period, which is at least measurably objectionable. One of the problems is the signaling of trolley lines with line poles along the track. There is a certain temptation in those cases to use upper left-hand quadrant signals.

But there is a broader question, in which the manufacturers are interested. The matter of uniformity is very important in railway operation, and cannot be passed over lightly. There is a real necessity that signaling practice should be uniform as between one railway and another and as between steam railways and electric railways.

Mr. Anthony (Pennsylvania Ry.).—In my judgment, the change to the left-hand side is desirable, and would cure most of the troubles in the location of signals. It is not difficult to make the change, except from a commercial point of view, and there is no serious danger in making it. Some of the early signals on the New York Central Ry. pointed to the left, and were replaced by right-hand lower-quadrant semaphores when the new signaling system was put in. The change was made gradually and I never heard of any trouble due to the misreading of signals. A very good reason for proposing this additional change, is that standard signaling is coming to the front on electric railways. For roads having overhead trolley wires, left-hand semaphores (when semaphores are used) are practically a necessity, and if the Signal Association should not recommend the upper left-hand quadrant, the Interurban Railway Association would be justified in recommending practice in this case different from that of the steam railways. Taking into account the possible extension of electrification with overhead trolley lines on existing steam roads I believe that we should be justified in recommending the change now, rather than to wait until it is forced upon us.

Mr. Williams (West Shore Ry.).—We have a two-track railway where we operate steam and electric jointly, and have an overhead trolley. We were obliged to put in offset poles, but we do not have a very satisfactory signal, on account of the network of wires. If we could use the upper left-hand quadrant and use a straight pole, we could get a good view of our signals.

Mr. J. V. Young (Boston & Maine Ry.).—We have recently erected about 1,700 signals. In a number of cases we used the upper left-hand quadrant, and those signals operate very successfully. With the upper left-hand quadrant, you get the light out of the line of the poles, and I am in favor of the change.

Mr. Morrison (N. Y., N. H. & H. Ry.).—The signal bridges on our road have the signals suspended between the tracks, with the blades pivoted in the center; thus we have sufficient clearance to allow the blades to extend down between the trains.

*Abstract of a paper in the "Journal" of the Railway Signaling Association, August, 1909. (Secretary, C. C. Rosenberg, Bethlehem, Pa.)

†Signal Engineer, New York, New Haven & Hartford Ry., New Haven, Conn.

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New York City devotes itself this week to celebrating with appropriate ceremonies the 300th anniversary of the voyage of Henry Hudson, and the 100th anniversary of the voyage of the first commercially successful steamboat, Robert Fulton's "Clermont." It is difficult for us at the present day to realize the enormous importance of the successful application of steam to the propulsion of vessels at the opening of the 19th century. This importance arises from the fact that the invention of the steamboat antedated by nearly a score of years the invention of the locomotive and the consequent development of the railway as a medium of transportation. It is hard to comprehend to-day the difficulties in transportation and the resultant social, economic and political conditions of a century ago. There were in the thickly settled Eastern States a few good highways over which transportation was carried on by freight wagons and coaches; but in what were then the pioneer regions, lying only a little farther west, the roads were of the most primitive character. The rivers were still, as they had been from the earliest days, the main avenues of transportation, but the boats which plied upon them had to be propelled by human muscle, except in the case of estuaries, like the lower Hudson, where sails were to some slight extent available.

This lack of transportation facilities had been, indeed, one of the chief reasons why population had been slow in pushing westward. Two centuries had elapsed from the time of the first settlement in Virginia until Fulton began steam navigation with the "Clermont," and those two centuries had seen a remarkable development of the states along the Atlantic Coast, so that population was even crowded in some sections. But the far more fertile lands only a little farther west, as we now count distance, were peopled only by a few scattered pioneers. It was indeed the development of the steamboat following upon Fulton's pioneer work that enabled the surplus population of New England and the Middle States to push rapidly out into the new West, with its boundless resources.

At the present day, all methods of transportation have to submit to the economic test; and if they cannot meet the requirement of operation at a cost not exceeding a small number of mills per ton-mile, they are left behind in the competition and become obsolete. There was nothing like this in the early steamboat days. The steamboat on the river had no competitor other than the horse-drawn coach or the ox wagon for 20 or 30 or 40 years. Indeed it was not until after the Civil War that the competition of the railway with the river steamboat became effective all over the country. By reason of these economic conditions, practically all rivers of any size became available for steam navigation. Vessels of even very shallow draft could run and make money for their owners for they could charge what rates they pleased. The "Clermont" itself drew only 2 ft. of water.

Under these conditions it was not strange that the steamboat was rapidly introduced on inland waters all over the settled United States as soon as Fulton had demonstrated its success. On the ocean the success of steam navigation was much longer delayed, for the sailing vessel was available to give a service highly satisfactory under the conditions of that day. The steam engine had to reach a much higher development before it could be applied to ocean navigation with commercial success and its complete victory over sails was not attained until after the close of the 19th century.

That Fulton was not the only inventor of the steamboat and that other ingenious men deserve large credit for their notable work in the application of steam to vessels has been well settled and was indeed shown in the paper published in our last week's issue. Further data as to some of these inventors are given by a correspondent in this issue. It was undoubtedly Robert Fulton, however, who first combined the mechanical and business ability to make the steamboat a commercial success; and the voyage of the "Clermont" is rightly given vast importance because of the new epoch that then began in the life of the young nation.

The use of oil in road maintenance and construction has been a great boon; but altogether too much has been claimed for oil-treated roads, particularly by those who have promoted the systems of road construction in which oil is mixed, by one means or another, with ordinary dirt. Only the very credulous would ever expect that "just as good" as asphalt pavements could be made by any such method.

Elsewhere in this issue will be found a strong letter from Mr. J. L. Campbell, M. Am. Soc. C. E., of El Paso, Tex., giving the results of investigations of so-called petrolithic pavement, made by him in view of the use and proposed extension of the petrolithic system of road construction in El Paso. There may also be found two valuable reports reviewing the history and practice of oiled road construction in Los Angeles. One of these reports was made by Mr. Homer Hamlin, M. Am. Soc. C. E., City Engineer of Los Angeles, and the other one was prepared by Mr. W. M. Humphreys, Inspector of Public Works in the same city. Each report is addressed to the Board of Public Works of Los Angeles. These reports are particularly valuable in that they point out the weak features of dirt as a basic material for oil impregnation in the preparation of roadways. They are also valuable as indicating proper substitutes for dirt where oil is to be relied upon as a binding material, and as showing how these substitutes may be increased in rigidity and permanency of material to meet different degrees of traffic.

We wish to call particular attention to what both Mr. Hamlin and Mr. Campbell say as to the unfortunate part played by the real-estate speculators in the choice of methods of road and pavement construction. The bane of municipal development throughout the length and breadth of this country is the practically uncontrolled power of real-estate developers, whether speculators or not, in the laying out and improvement of additions to city streets. Under such conditions, neither the street plan nor the methods of improvement adopted are chosen with a view to future needs; instead, the temporary interests of the real-estate boomers are served, and, this done, they get out from under as soon as possible, leaving purchasers for permanent investment, and taxpayers and citizens generally, to suffer. Is it not high time for reform?

Possibly some of our readers may not appreciate what an extremely valuable portion of Engineering News is the department devoted to "Letters to the Editor." Some of the discussions which appear in this department contain data of the greatest importance to the profession.

We think it worth while to call especial attention here to the discussion in that department in the present issue, concerning the construction of earth dams, contributed by Mr. James D. Schuyler and Mr. F. C. Finkle. Particularly noteworthy is Mr. Finkle's record of experiments to test the rate of percolation of water through long pipes which were filled with sand and clay under such conditions that they seem to have fairly represented a core or section taken through an earth dam. His experiments corroborate what is, we believe, generally accepted by the profession—that earth dams eventually become saturated, due to the slow passage of water from the reservoir side.

Mr. Finkle's experiments were apparently terminated when the water percolating through the section began to show discoloration. It was assumed, probably, that water so passing would gradually carry away the clay in the section and thus increase the rate of flow. It is not quite certain, however, that this actually would occur. Possibly, after some of the clay near the down-stream end of the section was washed away, the water might become clear again.

It would be interesting also to see what would be the result of graduating the material in the tube, putting the finer material at the water end and then graduating from fine sand to coarse sand and gravel. In this case, it is manifest that the more porous material in the lower side would not be saturated, and it is possible that the flow of the clay might be arrested so that the dam would remain tight. The experiment might be varied, also, by allowing sediment to accumulate on the upper end of the section, as in a natural silt-bearing stream, and determining whether the flow became checked.

It is of interest in this connection to study the experiments made with the model dam erected under the direction of Mr. C. M. Saville at Gatun, Panama, described in Engineering News of Dec. 24, 1908. Here the flow was almost wholly checked and the few drops of water that at last trickled through flowed entirely clear. Of course the head was very small, compared with what Mr. Finkle used; but, on the other hand, the length of the section through which the water passed was proportionately reduced. It may be added that Nature is all the time discharging water from rivers into porous strata adjoining; and the water in such cases, even though originally roily or muddy, is discharged entirely clear.

Whenever a new material for engineering work comes into use there is apt to be confusion in nomenclature and great diversity in methods of analysis or test. With present-day facilities for interchange of ideas and of information as to practice, much of this confusion may be avoided by an intelligent attempt to secure uniformity. Such an attempt is now being made in relation to the analysis and test of the bituminous materials for use in road construction that are coming to the front so rapidly in the United States—as they have previously done in France and England. To aid in this laudable effort we reprint elsewhere in this issue a circular in which analyses and tests for bituminous materials are given in a condensed but usable form. The circular has been issued by a committee of the American Society of Civil Engineers, and deserves serious consideration by state and city highway commissions, city engineers, road superintendents and chemists engaged either publicly or privately in testing bituminous materials designed for use in road construction.

As we have previously stated in a brief news note, the committee named has undertaken to collect information regarding the use of bituminous material in road surfacing, as well as copies of analyses of such material. Blank forms for reporting such data may be obtained from the secretary of the committee, whose address is given in connection with the article elsewhere in this issue. This effort to collect data is also highly commendable. If it meets with the response it deserves from those having such information at their command, the committee will be enabled to present a report which will exhibit current practice in various parts of the country.

We noted in our issue of Aug. 12 the reappearance of the old scheme for leasing the waterworks of Philadelphia to a private company. Apparently those who rule the political destinies of Philadelphia have gaged public opinion and seen the folly of defying it to the extent of forcing through this measure. Indeed, there is some reason to believe that the scheme to secure a lease has had no other backing than that of its indefatigable promoter, Nelson C. Green, of Providence, R. I. However, a definite quietus was given to the talk concerning the proposed lease by the passage on Sept. 16 of resolutions by the City Councils, reciting that

> no necessity exists for the city to surrender or dispose of its control of the water-works, and that they [the councils] hereby unalterably dissent to any and all propositions looking to the lease, sale or disposal in any manner whatever of said works.

These resolutions were adopted by both branches of the City Councils, practically without opposition. If the city authorities will now follow up this very proper action by the establishment of a meter system to check waste, they will do much to renew hope in those who despaired of seeing anything good come out of Philadelphia.

The Record-Breaking Flood at Monterrey, Mexico.

Every engineer interested in any way in hydraulic work (and this includes a pretty large proportion of the profession) will follow with interest the remarkable record given in this issue of the recent disastrous flood in the city of Monterrey, Mex. We are fortunate in being able to present complete data of this unprecedented flood, furnished to us by the Chief Engineer of the Monterrey water-works, Mr. G. R. G. Conway, M. Am. Soc. C. E.

The reader who follows Mr. Conway's article will see that this flood at Monterrey far surpasses all floods ever recorded in the history of engineering, in the volume of water sent down from a small drainage area. In the larger rivers of the eastern United States, the variation in volume between the lowest stage in times of drouth and the highest recorded floods may be taken as from 300 to 1,000. But at Monterrey the ratio between the lowest stage of the water and the highest flood is infinity. The Santa Catarina River at Monterrey is seldom anything but a dry channel. Only two or three times during the whole year does any water at all flow down it. For fully 350 days in the year, on the average, the river bed is entirely dry. Further than this, the drainage area of the river above Monterrey is not large, less than 600 square miles.

We may give a better idea to the general reader, perhaps, by saying that if this watershed were located in New England, the total length of the Santa Catarina above Monterrey would be little more than 30 miles, measuring up to the point where the river became a small brook. And yet, on the night of Aug. 27 last, there flowed down this dry river-bed a flood actually greater in volume than the torrent which sweeps over Niagara Falls. Remembering that the slope of the river is comparatively steep, it is no wonder that this torrent swept away everything in its path, and that the low-lying parts of the city of Monterrey were wiped out so suddenly that the dwellers there had no time to escape.

What the loss of life was among the poor Mexican peons, who were the principal inhabitants of this part of the city, will never be known even approximately. Mr. Conway's estimate of 5,000 lives lost, however, makes the Monterrey flood rank with the hurricane at Galveston and the Johnstown disaster of 1889, among the greatest calamities due to floods that were ever recorded.

The volume of water which passed Monterrey, according to Mr. Conway's careful measurements and computations, is given as 271,500 cu. ft. per sec. How enormous this discharge is may be appreciated by recalling that the flow down the Niagara River is only about 225,000 cu. ft. per second.

It may be of interest to compare the Monterrey torrent with floods in other rivers. Some of our readers may have witnessed the terrible flood in the Delaware River in October, 1903. That flood was caused, it will be recalled, by an unprecedented rainfall which swept also over the Passaic Valley and raised the Passaic River at Paterson far beyond all stages previously recorded. At Lambertville, N. J., a few miles above Trenton, the volume of the Delaware in this flood was determined to be 250,000 cu. ft. per sec., which, it will be seen, is materially less than the recent flood in the Santa Catarina. Yet the Delaware River above this point has a drainage area of nearly 7,000 square miles; furthermore, as every resident of Trenton can testify, this flood in the Delaware far surpassed all previous floods ever recorded in that river.

The table of flood flows and run-offs accompanying Mr. Conway's article is of surpassing interest to every engineer, particularly the column giving the cubic feet of flow per second per square mile of tributary drainage area for a number of large rivers. For example, the highest recorded flood of the Ohio at Cairo represented a flow of 3.3 cu. ft. per sec. per square mile of drainage area, and the Ohio flows from a territory in which the annual rainfall is much more than double the rainfall in the vicinity of Monterrey. The record flood in the Mississippi at St. Louis represents a flow of only 0.8-cu. ft. per sec. per square mile. The flood which wrought such destruction in Monterrey flowed at the rate of 590 cu. ft. per sec. per square mile; and in the small river near by from which Monterrey takes its water-supply, the run-off was at the enormous rate of 825 cu. ft. per sec.

These figures are of deep interest to every engineer engaged in work in the arid regions of the Far West. Over a large part of this territory where the rainfall is deficient and desert conditions prevail through the greater part of the year, there nevertheless occasionally occur sudden and very severe storms. These storms, falling on a surface bare of vegetation, often with steep slopes, are discharged into the valleys with almost the same rapidity and completeness as water draining from the roof of a house. It was such a storm as this near Pueblo, Colo., a few years ago, that swept down a dry arroyo, washed away a bridge on the Denver & Rio Grande Ry., and left a chasm into which a passenger train plunged before the track forces had even learned of the damage which the flood had done. It is a difficult problem that the engineer responsible for irrigation or water-supply works or hydraulic power plants in this region has to solve. Notwithstanding the scanty rainfall, provisions for spillways are necessary far beyond what would be required in a region of regular meteorological conditions like the eastern United States; and, as the records at Monterrey show, even the most liberal provisions may prove inadequate in case of such a terrific cloud-burst as that which caused the Santa Catarina flood.

Proposed Changes in Railway Signaling Standards.

The semaphore signal as applied to American railways has had the arm universally (barring a few exceptional cases) on the right hand side of the post, pointing away from the track. Until very recent years, the movements of the arm were universally in the lower quadrant; that is to say, the arm moved downward from the horizontal ("stop") position to the inclined vertical ("caution" or "proceed") positions. A few years ago the question of a change to the upper quadrant was brought before the Railway Signal Association, the arm in this case moving upward from the horizontal position. This system, which was discussed in our issue of May 9, 1907, was advocated very vigorously as presenting advantages in mechanical construction, in economy of operation and in making the signal specially conspicuous. Although the change affected a fundamental feature of signaling and involved very extensive alterations, it was received with general favor. The new or upper-quadrant arrangement is now the recommended standard of two technical associations, and has been adopted on some leading railways, while it is now before the American Railway Association for consideration with a view to its recognition by the standard rules.

Recently, however, another change has been suggested, which would supersede that just described. It consists in shifting the arm to the left-hand side, or track side, of the post, and having its movements take place in the upper left-hand quadrant instead of in the upper right-hand quadrant. This change was suggested in a paper presented recently before the Railway Signal Association, and was received with a rather surprising degree of favor by many prominent signal engineers. A brief abstract of the paper and discussion will be found elsewhere in this issue. After a prolonged and active discussion the matter was referred to a committee for consideration and members were requested to communicate their views to that committee. It is to be remembered that this association is largely representative of the railway companies and that its actions have much weight with railway managers.

The principal advantages claimed for the left-hand upper-quadrant arrangement are (1) that the signal will be more conspicuous, and more easily seen by the enginemen, (2) that it will be less liable to be obscured by lines of telegraph or other poles on the right of way, and (3) that it will be more convenient for such locations as rock cuttings, or where retaining walls, buildings, or electric wires would foul the ordinary right-hand arm with the signal post erected in its normal position. With the present arrangement it is sometimes necessary to offset the posts or to use bracket posts in order to have the arms in a position where they will readily be seen; while in a number of cases the installation of block signals has necessitated the moving of the telegraph pole line to prevent obstruction of the view of the signals. In other cases, signal bridges have been necessary for right-hand signals, where left-hand signals on posts at the side of the track would have been sufficiently conspicuous, had their use been permissible.

Left-hand signals were used by some roads in the earlier days of signaling in this country, and have been used also in recent years under special conditions. In fact, one objection made to recommending the new system was that enginemen are guided solely by the position of the arm (whether vertical or inclined) and not by its relation to the post; so that no standard arrangement is necessary and the arm may be placed on either side of the post according to requirements. This is at best a weak argument, for standard practice is highly desirable, both in regard to signaling in general and to the manufacture of the detail parts of signal equipment.

Another objection which has been urged is that the signal association is committed already to the change from the lower left-hand quadrant to the upper left-hand quadrant for movements of the signal arm. This has been adopted to some extent, and has been submitted to the American Railway Association as the highest authority on railway operation. For this reason, it is objected, to advocate the second and conflicting change at this time might make it appear that the former association was acting hastily and without due consideration upon matters of vital importance. To this it may be replied that, if the change is of such importance as to warrant its recommendation, the present is the proper time to bring it forward, before the higher asso-

ciation has taken action upon the earlier recommendation. At the present time, also, railways have only begun to adopt the system previously recommended, and signal companies have not entered largely into the manufacture of the standard designs of signal equipment for that system, so that the expense involved would be less now than at any other time. This commercial aspect of the question is of great importance, since efforts have been made during the past few years to standardize the designs for detail parts, in order to facilitate the work and reduce the cost of repairs and renewals.

An important point in connection with the proposed change is that electric railways are now working for a standardization of signal practice and equipment for such lines, and it is claimed that the new, or left-hand, system will be of special advantage to electric railways, by bringing the signal arms out of the range of the pole lines. It is, of course, very desirable that the standards for steam and electric railways should be the same, as far as possible, and the left-hand system appears to offer an opportunity for harmony in this direction. One reason for this harmony or cooperation is the increasing use of electric traction by steam railways, and the discussion showed that the signal engineers of the latter recognize this phase of development in its relation to signaling problems.

As far as the electric railways themselves are concerned, the matter is being taken up by the American Street and Interurban Railway Association. With the development of long-distance high-speed electric lines, and with the increase of their traffic, it is necessary that there should be a much more general use of the block system. This we have already insisted upon, in the light of numerous accidents which have occurred under the lax discipline and defective systems of operation which are in force on many lines of this character. The action of the electric railway association in this direction, however, should not be made independently of the study and experience of the steam railways and the signal association, and it is hoped that steps have been taken to ensure concerted action between the two associations.

LETTERS TO THE EDITOR.

The Behavior of Clays in Earth Dams Built by Hydraulic or by Dry Processes.

Sir: It is said that every disaster has its compensating features, and one of the compensations of an accident to works under construction like that which recently occurred to the hydraulic-fill dam at Necaxa, Mexico, is the lesson which it conveys regarding the behavior of materials under varying conditions, and the discussions which it brings out, by which the lessons are impressed upon the profession. I am glad to see that the account of the accident has been the subject of considerable discussion among engineers, and I was interested in reading the communication by F. C. Finkle, M. Am. Soc. C. E., in your issue of Aug. 5, 1909.

It seems to me of great importance that no erroneous conclusions should be drawn from the accident, and therefore I must challenge certain statements which I find in Mr. Finkle's letter. For instance, he says:

> Many hydraulic engineers have recognized the dangers incident to the use of clay, either nearly pure or mixed with fine sand and silt. *Not only do clay cores of this class of material consolidate with great slowness, if at all, but they are always liable to become re-saturated from impounded water, and thus lose cohesion to the degree of producing a slide.* (Italics mine.)

It is quite true that some clays, unmixed with sand, do consolidate very slowly, as demonstrated at Necaxa, although the length of time required depends greatly upon the climatic conditions and the manner of construction. In a dry climate, with intermittent applications of material sluiced into position, layer upon layer, it would be easy to build up a mountain of hard dry clay that would become absolutely solid and hard as so much shale. At Necaxa no intermission was ever given to allow the clay core to harden, and the climate is a very moist one, with annual rainfall of from 60 to 140 ins. But even with these conditions the clay core would have hardened in time, and sufficient water would have been pressed out of it by the superior weight of the clay particles descending by force of gravity, to leave the mass compact as in a state of nature in ordinary clay beds. It is well known that solid clay beds will form under water. The writer has seen at Seattle a sample of fine silt, the waste from hydraulic sluicing, which had solidified under several feet of water and become as hard as shale in the course of two or three months.

I do not feel positive that all clays will consolidate while actually under water, unless mingled with fine sand, although most of them with which I have experimented will do so. I have never known of a hydraulic-fill dam whose clay core had failed to become consolidated before construction was concluded, and they invariably reach a condition of greater density than the same materials placed by teams, scrapers and rollers.

The assertion that clay cores of dams

> are always liable to become re-saturated from impounded water, and so lose cohesion to the degree of producing a slide,

is quite contrary to my observation of the behavior of clays, and appears to me absolutely impossible. Dry clay, which has been exposed to the air in a way to permit it to part with its moisture, and consequently shrinks and cracks, will, of course, absorb water greedily, and in the process of expanding may become unstable, but under normal conditions clay in mass, as in a dam, is so protected from the air as to remain moist, and it will retain a certain quantity of capillary water by the surface attraction of its minute particles indefinitely. This is practically the condition of every earth dam, and there is no possible reason for asserting that the clay core of a hydraulic-fill dam is more liable to become re-saturated than that of any other earth dam. If Mr. Finkle's assertion be accepted as fact, every earth dam in the world, countless as they are, and many of them hoary with age, is still "liable to become re-saturated from impounded water," and so slide to destruction. This is absolutely preposterous. When clay once reaches a normal condition of maturity and solidity, as in a state of nature, it can never become "re-saturated," as its particles are so fine as to offer insurmountable frictional resistance to the passage of water under very great hydraulic pressure. The clay core-walls of ordinary earth dams, as built in England, for instance, are comparatively thin, and are subject to "re-saturation" from the reservoir water every time the reservoir is lowered, if such were possible, but no such action ever does take place.

Mr. Finkle believes in masonry core-walls for every earth dam of any type and of any considerable height, and I am aware that there are other engineers who have similar prejudice, but no advocate of masonry or concrete core-walls can deny that the highest earth dams in the world to-day have no other core-wall than a thin diaphragm of puddled clay. The San Leandro dam, the Tabeaud dam, the San Andres dam, and the Pilarcitos dam, rank among the very highest earth dams in the world, yet they have been in successful service for many years without evincing signs of "re-saturation" of the clay core-wall on which they all depend for water-tightness; except the Tabeaud dam, which has no special clay core but is homogeneous.

Mr. Finkle says again:

> Now, it must be obvious that a core of consolidated clay loses its value whenever the hydraulic pressure against it becomes too great. To meet this danger the base of the clay core in the Necaxa dam was apparently made very thick, and as a result the clay body was so large it did not drain out and the slide occurred. *In this case it proved impracticable to construct a clay core so thick that it would resist a water pressure approximating 200 ft. head. Had the core been made of less thickness it might have been built successfully, but it would have failed under the full reservoir pressure, sliding down the canyon instead of into the reservoir.* (Italics mine.)

The first lines of this quotation cannot be gainsaid, as they are axiomatic, and of general application. Even a masonry wall or any other structure "loses its value whenever the pressure against it becomes too great." I protest, however, against the succeeding statements. It did *not* prove impracticable to construct a clay core thick enough to resist 200 ft. head. Nothing has occurred leading to such a conclusion. In fact, there was evidence in the solidified and drained portion of the clay core clinging to rock-fills on either side of the center to show that the clay had been impervious under a head of more than 100 ft., even where the thickness was not greater than 20 ft. The clay core at Necaxa was over 300 ft. thick at base and over 70 ft. thick at the crest when the break occurred. It was never for a moment considered that this great thickness was needed to resist hydraulic pressure, but had it been made of less thickness the rock substituted for it would have cost much more, and much of the clay would have been wasted. In fact, I am quite convinced that 45 to 50 ft. of thickness of clay would have sufficed to withstand the head of 200 ft. quite as well as 300 ft. of thickness as built, and can see no reason whatever for the assertion made by Mr. Finkle that a thinner core than that used would have failed under the full reservoir pressure and slid down the canyon. The rock walls on either side of the thinner core would have been more stable than had the core been thicker, and therefore better able to resist the pressure of the reservoir tending to slide the structure on its base. The dam has a down-stream slope of 2 on 1, and up-stream slope of 3 on 1, with crest width of 54 ft. when finished. These dimensions are greater than ordinarily given to earth dams. Mr. Finkle has, therefore, no reason founded on either experience or theory for asserting that the dam would have failed under the full reservoir pressure with a core of less thickness.

The repairs of the break are being made on this very principle, as explained in my letter published in your issue of July 15, 1909, of reducing the clay core to a minimum, substituting more rock in the slopes, and the dam is not going to fail by sliding down-stream, notwithstanding the *ipse dixit* of the letter referred to.

The last paragraph of Mr. Finkle's letter draws a deduction which cannot be supported by the citation of any facts, either as applied to the Necaxa dam or in general. The construction of earth dams on bedrock without a masonry core-wall may offer "every inducement for the water to follow the bedrock and for the dam to slide," but the discouragements opposed to such action in any intelligently designed earth dam, with a properly prepared base, so far offset the alleged inducements as to render a slide of the dam bodily along the bedrock an impossibility. I know of no precedents which justify such an opinion, while in the particular case to which this discussion is applied the funnel-shape of the dam site, contracting in width going down-stream, the natural roughness of the stripped surfaces, the deep, wide core trenches, four in number, and the center core-wall of concrete reaching up into the puddle core five or ten feet from the surface of the bedrock, there is no more reason to apprehend a slide than if a core-wall extended all the way to the top, even with a dam near 200 ft. in height. The risk of accident or slides in hydraulic-fill dams is always greater during construction than at any subsequent period, but when the sluiced materials become drained and in their final position, even with dams as high as 200 or 300 ft., the risk of failure is no greater than with any other type of dam.

James D. Schuyler.

Los Angeles, Cal., Aug. 14, 1909.

[Proof of Mr. Schuyler's letter was sent to Mr. Finkle. The reply of the latter follows.—Ed.]

Sir: Engineers, like doctors, will occasionally differ, particularly regarding matters which are still in their experimental stage. This applies to the points raised in the foregoing communication from Mr. James D. Schuyler.

Mr. Schuyler stands as the leading exponent of high hydraulic-fill dams without any core other than hydraulicked material. I take a more conservative view of the subject and believe that earth dams, especially those constructed by hydraulic process, should have a concrete or other equally stable core wall, when designed to a height of 150 ft. or over.

This is all there is to the matter, so far as the individual opinions of Mr. Schuyler and myself are concerned, and were it not for the examples cited to justify his opinion and the suggestion that my statement is an *ipse dixit*, there would be no occasion for my saying anything further. It will be observed that none of the earthen dams cited by Mr. Schuyler were built by the hydraulic-fill process, that two are below 100 ft. in height and only one is slightly above 100 ft. high. The Pilarcitos and San Andres dams are 93 and 95 ft. high, respectively, and were constructed with 20-ft. cores of the best possible puddle. The remainder of the fill was carefully made, so as to surpass by far the results of any hydraulic fill ever made. The Pilarcitos slopes are 2 on 1 and 3 on 1, and the San Andres slopes more conservative, being 3 on 1 and 3½ on 1. Both dams were constructed under the supervision of Mr. Herman Schussler, M. Am. Soc. C. E., Chief Engineer of the Spring Valley Water Co., San Francisco, which of itself is a guarantee that the work could not have been better executed.

The San Leandro dam is the only one referred to over 100 ft. high, being 120 ft. in height, but with a 40 to 50-ft. puddle core, 38-ft. top width, 3 on 1 down slope and about 4 on 1 up slope. The whole fill was carefully made, wet and rolled, and no hydraulicking employed in its construction.

The only other dam mentioned by Mr. Schuyler is the Tabeaud, which is 100 ft. high at its up-stream toe. This dam has 2½ on 1 slopes on both sides, except the lower half of the up-stream face, which is 3 on 1 over a puddle slope. The whole dam was made of an excellent red gravelly clay, placed in thin layers, harrowed, wet and rolled.

I do not consider that any of these dams assist in deciding the question at issue, for the following reasons:

(1) They are all exceptionally well constructed by the old standard method of building earth dams, which I heartily approve and endorse, and are in no wise related to the hydraulic-fill method employed at Necaxa.

(2) They are all comparatively low dams, when dams from 200 to 300 ft. high are under discussion, and it cannot be assumed that even this class of construction will be conservative and safe much above the limit to which it has been successfully tried.

(3) Nothing is known about the state of saturation in these dams under different water levels in the reservoirs,

so far as I am informed. On the other hand many data on this subject have been given us by the Croes committee, Mr. Desmond FitzGerald and the government of Bombay, showing that other earth dams of clayey material slowly drain out, but later become re-saturated from impounded water. This, however, is not a serious menace to dams of the height referred to by Mr. Schuyler as examples, since a superimposed hydraulic pressure in the clay is not so likely to produce a slide under low as under high heads. The Necaxa slide did not occur until the hydraulic pressure reached more than 160 ft. head.

I claim that my opinions touching the necessity of thick cores, when nothing but hydraulicked material is employed, and the danger of constructing high dams of this kind with thin cores, are borne out by sound theory and can be demonstrated by experiments. Leaving out of consideration here the theoretical solution of drainage, percolation and saturation, based on the Poisieulle-Meyer law and other data of that character, which every engineer can apply to his own satisfaction, permit me to call attention to the following facts, which I have obtained by experiments:

Two sections of 30-in. pipe, one 38 ft. long and the other 76 ft. long, were fitted with tight wooden rings having a 3-in. projection on the inside of the pipe, fastened 8 ft. apart, and the pipes placed on a 45° angle with the lower end closed by a 1/16-in. mesh screen held in place by a cap of ⅜-in. rods. These pipes were hydraulicked full of sand and clay, about 1.1 parts sand to 1.0 parts clay and fine silt by measure, from the red sandy clay in Mill Creek Canyon, near Redlands, Cal. After the hydraulicked material had drained out and consolidated, its top was rammed and the space at the top of the pipes, as left from shrinkage, was filled with water. A tight cap was placed over the top end of the pipes and hydraulic pressure equal to 43½ lbs. per sq. in. at the lower end was pumped up, after making allowance for inclination of pipes. After this the clay in the pipes was again given time to drain and consolidate, after which the test was repeated with 87 lbs. pressure.

The mean of five such tests, the pipes being emptied and filled with new hydraulicked clay for each test, gave the following results:

With 38-ft. tubes and 43½ lbs. pressure, clear water appeared at the lower end of the tube in 63 hrs. 23 mins. after application of pressure, and roily water began to discharge two hours later, becoming thicker during the next 24 hours, when pressure was taken off.

With 38-ft. tubes and 87 lbs. pressure, water appeared in 22 hrs. 41 mins., becoming roily within half an hour after its first appearance and growing more so for 24 hours.

With 76-ft. tubes and 43½ lbs. pressure, water appeared in 189 hrs. and 53 mins. after application of pressure and became discolored in about 5 hrs. after its first appearance.

With 76-ft. tubes and 87 lbs. pressure, water appeared in 68 hrs. and 18 mins., becoming discolored in a little over three-quarters of an hour.

Afterwards the two tubes were filled with a puddle made from the same kind of material and the same pressures applied. The time required for the water to appear under the low pressure was over three times as long as with the sluiced material, and for the high pressure it was nearly twice as long. On account of the time and trouble required to separate the tubes into 19-ft. sections and again to join them as the puddle was tamped in, only one set of observations was made with the puddle filling.

At no time during the tests did the water appear to follow the sides of the tubes but came out in fairly uniform quantity over the entire area at the lower end of pipe; thus the wooden offset rings seemingly accomplished their purpose. The results of these experiments did not reveal anything new or startling at the time they were made, but corroborated other recorded data showing that water will percolate through the most indurated clays and rocks and that the velocity of percolation increases faster than the pressure.*

If water percolates through these substances it must saturate them, and while no danger exists from saturation of rock, it does exist in the case of clay, which loses friction and cohesion among its particles, when saturated, and has a tendency to slide and flatten out. The higher the saturation head in clays, the more complete becomes the separation of the soil particles by water, and a hydraulic pressure is exerted due to the mean weight of the mixed clay and water.

Under our state of knowledge as revealed both by experience and experiments up to the present time it, therefore, appears foolhardy to suggest, as Mr. Schuyler does, that a 45 or 50-ft. hydraulicked core will stand 200 ft. of hydraulic pressure, when backed up by porous material below it. It is more reasonable to suppose that such a pressure will simply force the clay out through the voids in the porous mass below. At least, I have such fixed opinions on this point, that I am willing to leave the experiment to some one else. The case is not comparable to earth dams of the old type, in which the puddle core only needs to be of slight thickness, because the whole structure is made as nearly impervious as possible by placing the earth in thin layers, wetting and rolling it.

This communication has lengthened out beyond what I expected before writing it, but the subject is one of so much importance to the engineering profession that I feel no apology is necessary. The construction of high earth dams, 150 ft. or over, without core walls of concrete or other materials of a rigid nature, is yet in the purely experimental stage, and it is fortunate to have the matter presented in its most favorable aspect by as able an exponent as Mr. Schuyler.

Respectfully,

F. C. Finkle.

Los Angeles, Cal., Sept. 3, 1909.

*"Principles and Conditions of the Movements of Ground Water," by F. H. King, Part 2, 19th Ann. Rept., U. S. Geological Survey.

The Credit for the Invention of the Steamboat.

Sir: The article entitled "Robert Fulton's Contribution to the Success of Steam Navigation" in your issue of Sept. 16, calls for a reply. We are witnessing a national celebration of the fame of the man who didn't invent the steamboat. Robert Fulton built the first commercially successful steamboat. His place as inventor is a minor one, and his career as a builder of numerous early steam vessels is shadowed by his unjust claims to the inventions of others and his usurpation of their rights.

Among the names of the more or less successful inventors whose work preceded Fulton's, three stand out conspicuously: Fitch of Pennsylvania, Morey of New Hampshire, and Stevens of New York. They are mentioned half-heartedly in the publication of the Hudson-Fulton Celebration Commission from which your article was extracted, and incomplete and inaccurate summaries of their work are there given. Each gave many years' work to this great mechanical evolution, and they reached their fullest success in the order named.

Following Fulton's commercial success, long-drawn-out legislative and judicial battles were fought involving the rights of several claimants. Much hinged on the decision of who was the inventor of side paddle-wheels. Fulton's first patent granted in 1809 lays no specific claim to the invention of this mechanism. In 1811 he secured a second patent in which this claim is set forth: "Having been the first to demonstrate the superior advantages of a water wheel or wheels, I claim as my exclusive right the use of two wheels, one over each side of the boat to take the purchase on the water."

Samuel Morey's first boat was built as early as 1793, and was fitted with a paddle-wheel placed in the bow of the boat. The boat was run on the Connecticut River between Orford, N. H., and Fairlee, Vt. His second boat was built in New York about 1794, and the paddle-wheel was placed in the stern. In 1797 he built a boat at Bordentown, N. J., to which two wheels were fitted, one over each side of the boat, carried on a transverse shaft containing a crank in the middle, in all respects involving the principles now universally applied in all side-wheel boats. This boat was exhibited with entire success in Philadelphia, and patents were issued to him covering, probably in a very general way, his inventions. The burning of the Patent Office in 1836 destroyed the records of these patents, and the originals, with the exception of one dated March 25, 1795, have been lost. Previous to the building of the Bordentown boat, Chancellor Livingston offered Morey $7,000 for the patent right to use his invention on the North River and to Amboy, N. J. This offer was declined by Morey as being an insufficient amount. Following the successful trials of the Bordentown boat, Morey made arrangements with Dr. Burgess Allison and other gentlemen to put steamboats into commercial use, but through a series of financial losses Dr. Allison was unable to proceed with the work. Morey used paddle-wheels in his first experiments and stuck to their use until their finally successful application was wrought out in his boat of 1797.

Fitch went to France in 1793 seeking capital which should enable him to perfect his invention and to generally introduce steam navigation. In 1794 he worked his way back to America as a common sailor, having deposited his specifications and drawings with the American Consul at L'Orient. In 1801 Chancellor Livingston was appointed Minister to France. He associated himself with Fulton there. From the writings of William Alexander Duer, legislator, jurist and president of Columbia College, we learn that Mr. Vail, Consul at L'Orient, at Livingston's request, loaned all Fitch's plans and specifications to Fulton, who kept them in his possession several months. Fitch was dead.

A recently published cut of a model of one of Fitch's boats shows the use of a propelling mechanism consisting of endless chains along each side of the hull, carrying paddles and running over pinions carried on shafts projecting through the sides of the hull. Fulton in his early plans for his experimental boat built in France in 1803 announced the contemplated use of endless chains, or, in his words "bands of paddles" running from bow to stern. Clearly he did not "successfully demonstrate the superior advantages of a water wheel or wheels" until several years after Morey had used them with entire success in his Bordentown boat. Fitch at various times tried the use of wheels, but never with success. The legislative committee appointed in 1814 to investigate the validity of the 20-year monopoly granted to Livingston reported in 1817 that it found the boats built by Livingston and Fulton were essentially the inventions of Fitch patented by him in 1791. Evidently this committee knew little of Morey's work previous to its report, as shown by a forceful letter now in existence written by Morey in 1815. Morey was unable to make satisfactory arrangements with Chancellor Livingston for the utilization of his invention. In 1798 Livingston stated that the use of vertical wheels was "out of the question." Possibly his temporary conviction that the paddle-wheel could never be used successfully and his faith in his own impracticable contrivance was the cause of the break in his relations with Morey a few years previously.

Dr. Allison's financial failure blasted Morey's Philadelphia enterprise; Livingston's legislative monopoly granted on the death of Fitch about the year 1798 shut him out from the exploitation of his work in New York, the locality affording the best commercial opportunity in the country, and a few years later the unjust claims of Fulton's patent put a nation-wide prohibition on all attempts to use side paddle-wheels. The spirit of genius burned within this man. Eighteen patents were granted him for various inventions, several of which pertained to the application of steam. He died at Fairlee, Vt., in 1843, maintaining to the last his claims as the inventor of many of the devices "through which Fulton and Livingston were enabled to succeed." The name of Lake Morey, a beautiful sheet of water at Fairlee, where one of his steamboats was run, is his only memorial.

Fulton's "invention" consisted in the application of one of Boulton & Watts' well developed steam engines to a propelling mechanism devised by others. His patent of 1809 contains a long description of his claims to discoveries pertaining to the velocities and resistance of boats, which were paraphrased without acknowledgment from Charnock's "History of Marine Architecture," published in 1803—always a sore spot for his descendants and defenders.

Were the truth generally acknowledged that Fulton was afflicted with a full share of humanity's weakness for fame, and that this motive went so far as to work injustice to the rights and honors of others, then those who know the history of the steamboat other than superficially could rejoice in a national celebration which should commemorate both the real inventors of the steamboat and Fulton's great work in making it a commercial success.

James L. Davis.

New York, Sept. 18, 1909.

[We give space with pleasure to this letter, which awards credit where credit is due; but we would call attention also to the fact that it is the rule rather than the exception for the promoter or business man, who introduces a new epoch-making invention to public notice, to be considered the inventor by the general public. Deplore it as we may, the public renders its homage to spectacular success and publicity, and seldom stops long enough to inquire carefully as to how the spectacular success was attained. And the public is not altogether wrong after all. It is, as a rule, more difficult by far to make an invention—even a meritorious invention—succeed than to originate the invention. Doubtless the promoter or financier who furnishes the money and the business ability to introduce a new invention to the public and make it go ought to give full credit to the original inventor. Yet even then the public often persists in connecting the invention with the name of the man who has been the chief figure in exploiting it.—Ed.]

STATISTICS OF THE SOUTHERN STATES, in a circular issued recently by the Southern Commercial Congress, an association of business men whose aim is to make the South more commercially important, include the following items of information: Of the 620,000,000 acres contained in the 16 southern states, not more than 25% is under cultivation. The combined coast line of these states is twice the length of the Pacific coast and three times that of the North Atlantic and they contain 2¼ times as many miles of navigable streams as all the rest of the states together. In the entire South, there are $28,000,000 less capital invested in manufacturing than in the State of Pennsylvania alone. The average population of the southern states is 39.3 per square mile, while that of the 16 northern states east of the Mississippi is 128 per square mile.

Density and Draining Capacity of Artificial and Natural Mixtures of Sand and Gravel.

By E. C. MURPHY,* M. Am. Soc. C. E.

In the U. S. Geological Survey laboratory investigation of water transportation of debris it has been necessary to study some of the characteristics of mixtures. With permission of the Director and the Chief Hydrographer, certain principles, learned in that investigation, underlying the density of mixtures and the water that

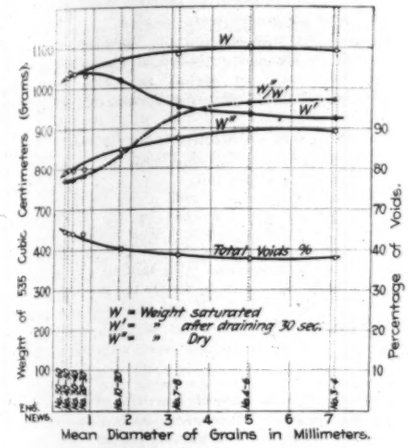

Fig. 1. Weights of Saturated, Drained and Dry Gravel.
(Plotted from the table on this page.)

can readily be drained from them are here presented.

The weight of a given volume of a sand or fine gravel depends on the moisture it contains and the degree of consolidation. In a moist condition it occupies more space and weighs less per cu. ft. than when thoroughly dry. The voids in loose sand may be 30% greater when it contains about 6% of moisture than when it is either dry or saturated with water. Maximum density and minimum voids are secured by depositing the sand slowly in water while the vessel is being shaken or tapped on all sides. The principles to be noted apply to debris in this condition of greatest density.

The debris used was sand from the Sacramento River and fine gravel from the American River. It was separated into eight sizes by sieves. The mean diameter of the grains of each size of separation was computed from the specific gravity and the weight of 500 to 1,000 grains.

The accompanying table gives data for the eight sizes of separation. The column headed "Drained" gives the weight of 535 cu. cm. after draining 30 sec. Some of the data of this table are plotted in Fig. 1.

TOTAL VOIDS.—The total voids in these sizes of separation are seen to decrease from 45% for 50-60 to about 38% for the 6-8 sieve and to remain about 38% for the larger sizes. Theory indicates that the voids in a mass of equal spheres symmetrically placed in the most compact manner is 26% and is independent of the size. The minimum total voids in these separated sizes of river debris is 37.6%.

WATER QUICKLY DRAINED.—The curves W and W' practically coincide for sizes smaller than 0.8 mm. They diverge rapidly for sizes 1 mm. to 4 mm. and are nearly parallel for the larger sizes. That is, when the grains are smaller than 0.8 mm. drainage is very slow, capillary action holds the water in the sand for a long time. If the grains have a size of 4 mm. they readily part with 75 to 85% of the water they contain.

MIXTURE OF MINIMUM VOIDS.—This is evidently a graded mixture, the voids in the largest size being filled with a smaller size, the voids in this second size being filled with those of a smaller size, etc. Fig. 2 shows the total voids in various mixtures of two of the sizes in the table. In each of these cases the voids decrease as the finer material is added until the mixture contains 33% of the fine after which the total voids increase as the fine is added. If only two of these sizes are available the 4-6 and 50-60, mixed 67% of the former to 33% of the latter, give the densest mixture, the total voids being 25.8%. The ratio of the mean diameter of these sizes is 16.2. Various combinations of three of these sizes was tried with the result that the proportion can be varied several per cent. without materially altering the percentage of total voids. A mixture of 4-6, 10-20 and 30-40 in the proportion 2.5:1:1 had 27% total voids. When four of these sizes were used in a mixture the proportions could be varied several per cent. without material change in the per cent. of total voids. A mixture of 4-6, 10-20, 30-40 and 50-60 in the proportion 2.5:1:1:1 had 26% total voids. The smallest per cent. of total voids with any combination of these eight sizes was 25.8%.

When more than 33% of a size smaller than 0.8 mm. was mixed with any size larger than 1 mm. only a very few drops drained from 535 cc.

Drainage from a mixture of two sizes that drain freely when used separately decreases as the finer is added until about 33% is used after which it remains nearly constant and is somewhat less than from the fine size when used alone.

NATURAL MIXTURES.—Water made deposits of debris vary greatly in the proportion of the sizes of the particles. Rapid changes in the velocity of the stream forming the deposit causes separation of the sizes and forms local deposits of abnormal proportions. In the large deposits on a long straight stretch of channel free from obstructions we find an important principle governing the proportion of size of particles. The mechanical analysis curves of Fig. 3 show this principle.

Curves 1, 3, 4, and 5 are for material from the bed of Puta Creek near Davis, Cal. The flood discharge of this stream occasionally exceeds 30,000 sec.-ft. Curves 6 and 7 are for material from the bed of the American River, 6 miles above the mouth; curve 10 is for material from the bed of the Sacramento River near Sacramento, Cal.; curve 9 is for material from San Francisco Bay in Berkeley, Cal., and curve 11 is for material from the sea beach near San Francisco. The parabola A used for the ideal proportioning of concrete aggregate is drawn for curve 6 and parabola A' for curve 1.

It is easily seen from these mechanical analysis curves that as the material increases in coarseness the proportion of sizes changes, the proportion of the smaller sizes gradually decreasing as the coarseness increases. In other words the uniformity coefficient increases as the coarseness increases. As the coarseness increases the mechanical analysis curve gradually approaches the parabola of the same size of coarsest material.

The total voids in these mixtures decrease as the coarseness increases or as the mechanical analysis curve approaches its parabola. The total voids in mixture 6 are 33%, in mixture 5 25.5%, and in mixture 4 23.3%.

The water drains very slowly from all these normal natural mixtures only a few drops draining from 535 c. c. in 30 secs.

TABLE SHOWING VOIDS AND OTHER CHARACTERISTICS OF SAND AND FINE GRAVEL.

Name of sieves.	Mean diameter of grain, m m.	Weight, in lbs., of 535 cu. cm. Saturated, W.	Drained, W'.	Dry, W''.	Total voids, %	$K = \frac{W''}{W'}$
50-60	0.305	1,032	1,032	795	44.7	.770
40-50	0.377	1,045	1,041	800	44.4	.770
30-40	0.508	1,039	1,037	803	44.2	.774
20-30	0.789	1,033	1,032	807	43.9	.784
10-20	1.715	1,072	1,025	856	40.6	.835
6-8	3.19	1,082	950	884	38.6	.935
4-6	4.96	1,100	937	898	37.6	.958
3-4	7.10	1,093	924	895	37.8	.968

RAILWAY LOSS AND DAMAGE CLAIMS and injuries to persons cost the railway companies of the United States $56,700,000, according to statistics collected by Mr. Slason Thompson of the Chicago bureau of railway statistics. This is an increase of nearly $10,000,000 over the amount paid in 1907, while ten years ago, in 1898, the payments were only $12,182,000. These payments now absorb nearly 2% of the gross earnings. In some sections the damage claims are much heavier than in others. In Texas, in 1908, 5.19% of the railways' revenue went to pay claims for losses, damages and injuries to persons.

CITY GOVERNMENT BY COMMISSION has been decided on as the subject for the annual contest for the William H. Baldwin prize of $100 offered by the National Municipal League, North American Building, Philadelphia. The competition will be limited to undergraduates in any colleges or universities of the United States which offer "distinct instruction in municipal government." The competition will close on March 15, 1910. More detailed information may be obtained from Prof. William Bennett Munro, Harvard University, Cambridge, Mass., Chairman of the Committee on Coordination of Instruction in Municipal Government.

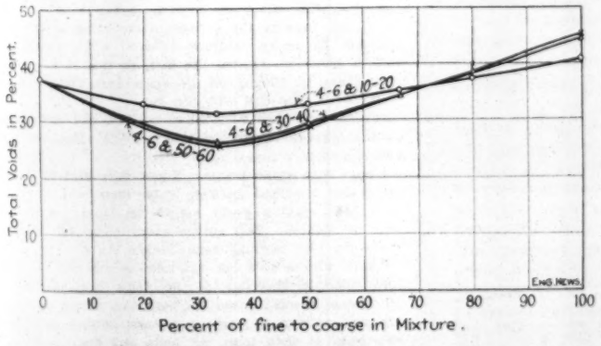

FIG. 2. TOTAL VOIDS IN VARIOUS MIXTURES OF SAND AND GRAVEL.

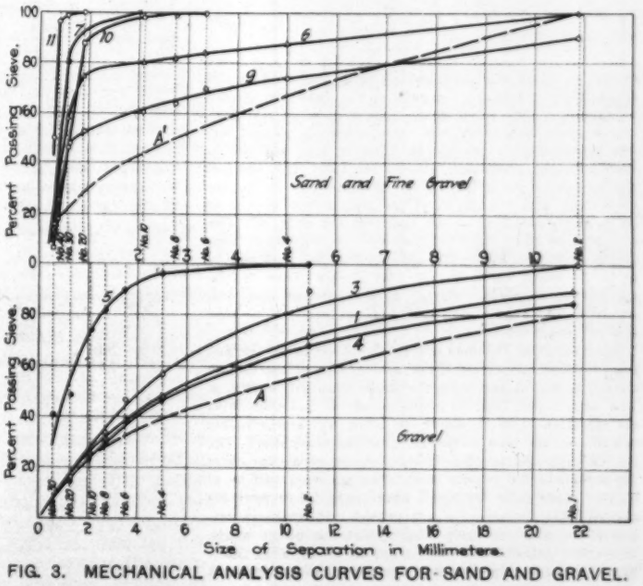

FIG. 3. MECHANICAL ANALYSIS CURVES FOR SAND AND GRAVEL.

*Engineer, U. S. Geological Survey, Berkeley, Cal.

Plans for the Spillway Dam at Gatun, Panama Canal.*

A concrete dam in ogee form has been decided upon for the barrier in the spillway of Gatun Dam. The proportions are such that the nappe will adhere to the masonry, and the curve at the toe will be sufficiently long to prevent any great disturbance being caused in turning the water back to the horizontal direction. By using the curved crest line the energy of the fall may

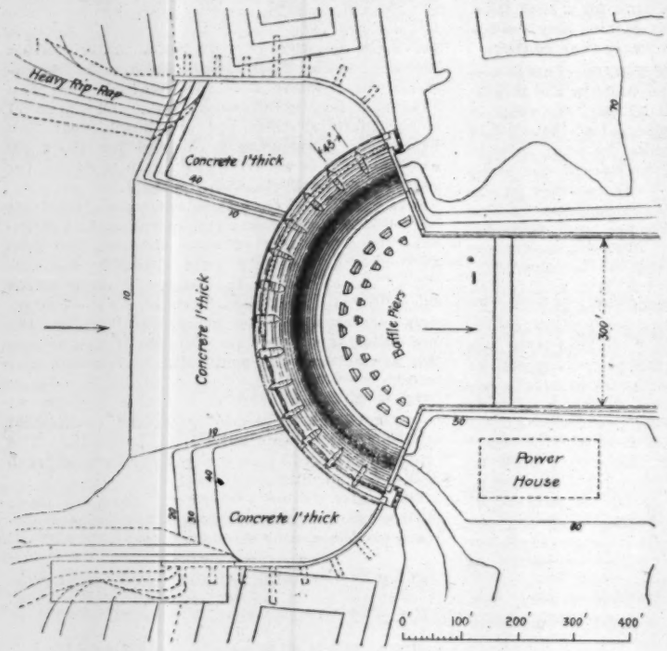

FIG. 1. PLAN OF THE GATUN SPILLWAY DAM.

be utilized to destroy to some extent the velocity of the water. Additional positive check will be provided in the form of masonry baffles, for otherwise it would be impossible to predetermine the point below which regular flow will be established.

In selecting a location for the spillway by which the height of water in Gatun Lake will be regulated, a hill about midway between the ends of the Dam was chosen because in it the surface of the rock is about at sea level, and a good foundation was thus procured without excessive excavation. A channel 1,200 ft. long and 300 ft. wide has been excavated through the hill. This channel will be closed at its south or upstream end by a concrete dam, with foundation at sea level at the toe and at 10 ft. above sea level at the upstream end (Fig. 1). The dam will be 93.04 ft. thick from heel to toe, 630 ft. long on the crest line across the channel and the crest will be at 69 ft. above sea level. It will contain about 140,000 cu. yds. of concrete. On top of the concrete dam will be built the regulating works, plans for which have not yet been approved.

After study of the maximum flow to be cared for and the probable rate of discharge over a dam of the section shown in Fig. 2 and with the heads that will obtain, it was determined that 14 gates, each 45 ft. wide, with sill elevation at 69 ft. above sea level, will give absolute control of the lake under all possible conditions. The top of these gates when closed will be at 87 ft. above sea level and the bottom when they are open will be at 92 ft. Since little drift will have to be taken over the spillway dam, owing to the large size and irregular outline of the lake and the prevailing direction of the winds, the crest gates have been planned to open to Elev. 92, which will give sufficient opening to allow any drift that may reach the dam to pass over. To prevent any large drift that may go over the dam from damaging them, it is proposed to face the baffles with heavy ribbed cast-iron plates which will distribute the shock over the concrete.

The cut through Spillway Hill has been paved and the sides are being lined with concrete, so as to give a smooth channel through which the Chagres River may discharge after the West Diversion is closed. Before the West Diversion is closed preparations will be made to build cofferdams, under shelter of which the concrete of the main spillway dam may be placed later.

It is considered necessary to have positive lake regulation during the construction of the spillway dam and of the locks, and in order to obtain this, and at the same time to test some of the Stoney culvert gates intended for the locks, three of the piers between the crest gates will be made much larger than the others. Culverts will be left through them at a low level and some of the gates already contracted for will be installed. In order at the same time to test one of the cylindrical valves for the lock, a fourth large pier will be constructed in which to install one of them. This valve will be set at a somewhat higher elevation than the Stoney gates and will, therefore, not assist in the regulation of the lake at low levels.

Preparations for installing the cofferdams have been made. The West Diversion will be closed and the flow of the river will then be through the channel and may be continued here as long as desired. During this time the ends of the spillway dam, which will be founded upon the rock at elevation 40 ft. above sea level, may be constructed, as they will be well above the surface of the water flowing through the channel.

The lake should drain down to about 13 or 14 ft. above sea level during the dry season, and construction of the dam should, therefore, begin at that time of the year, when it is desired to fill the lake. The cofferdams may then be put in, shutting off the water and allowing the concrete to be placed. As soon as a few feet of concrete have been put in, the culvert gates should be opened and left wide open during the construction, except as they may be occasionally closed to permit the examination of the masonry inside the culverts. If they are left open in this way it will be possible to keep the construction of the dam ahead of the rise of the lake, so that there will be no danger of overtopping the new masonry. The dam should then be completed and the crest gates installed. It will be impossible to put in the machinery for five of these gates at the time they are installed, as the operating machinery for the three Stoney culvert gates and the one cylindrical gate will prevent it. There will, however, be sufficient available lake regulation with the nine crest gates, three Stoney culvert gates, and one cylindrical valve.

When it is desired to remove the Stoney gates and the cylindrical valve to the locks, the culverts will be closed by temporary gates at their upstream ends, thus shutting off the water and allowing the gates and valve to be removed. The culverts will then be filled with concrete. As soon as the gates and the valve have been removed the operating machinery for the remaining crest gates can be installed, completing the spillway.

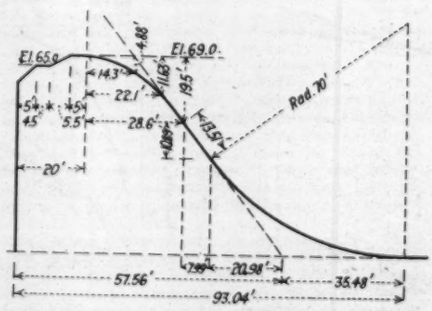

Fig. 2. Section of the Spillway Dam at Gatun, Panama.

*From "The Canal Record," Sept. 8, 1909.

STIMULATING DEMAND for electric current is reported soon to be attempted by the city of Aberdeen, Scotland, by purchasing a large stock of electrical heating and cooking apparatus which it will rent to customers.

Annual Convention of the Roadmasters' Association.

The 27th annual convention of the Roadmasters' and Maintenance of Way Association was held at the Ebbitt House, Washington, D. C., last week with 48 members registered in attendance. The opening session on Tuesday was called to order by President A. E. Hansen, of Green Bay, Wis. (C. & N. W. Ry.), in the chair. An address of welcome was made by Mr. D. W. Lum, Chief Engineer of Maintenance of Way, Southern Ry. Reports of officers were presented and 27 new members were elected.

In the afternoon session on Tuesday a report was read on the best method of changing rail or laying new rail on steam railways, by John Barth, of Mattoon, Ill., Supervisor C., C., C. & St. L.

The report was substantially as follows:

This report gives actual experience, in taking up 80-lb. rail and laying 90-lb. rail.

To unload the new rail I used a rail unloader, which was operated by air, furnished by the work engine, which took a foreman and five men besides the train crew to operate. Any good handy man could run the loader. I made comparison with loading and unloading rail, and found that we could handle the rail considerably cheaper with the machine. It cost to unload the new rail and fastenings, per mile:

Labor	$9.75
Work train service	9.58
Fuel, oil and waste	7.58
Making, per mile for unloading, a total of	$26.91

This was on single track where we had an average of 17 trains during the ten working hours. To get the above estimate of cost of unloading I took total cost of unloading 65 miles of rail, and divided by 65 which gives the average cost per mile. Some days were hung up on account of trains and did very little work, and other days we could do more.

We loaded the old rail with the rail loader, and it cost practically the same to load it as it did to unload the new rail.

In laying this rail I used gangs of one foreman, assistant foreman, time keeper, and two flagmen, and 44 men. Had my gangs organized as follows:

6 men with claw-bars pulling spikes.

3 men with spike mauls to loosen up spikes that were stuck and to knock down stubs.

4 men throwing out the old rail.

1 man with nipping bar to cant the old rails up out of the old bed, and 3 men to shove it out.

3 men driving plugs in the old holes, which should be distributed ahead of the work.

In taking up light rail and laying heavier rail, pull the outside spikes. In doing this, I had 1 man with an adze to adze off the very highest ties only and to cut off the plugs that stick up.

12 men with tongs to set in the new rail, which should be set in one rail at a time.

1 good hustling fellow to put in the expansion shims and keep the rail gang moving, using steel cut nails for shims, making the expansion according to the thermometer by using different sizes of nails, putting the nail in crosswise against the ball, so that it will be out of the way in putting on the angle bars. The first few trains over, this nail will slip out.

2 men with bars with claws on one end and pointed on the other to shove the rail into the spikes at center and quarters.

4 men with spike mauls. These men start off leaving eight ties unspiked between each man, and go ahead, each man spiking every eighth tie from the last one that he spiked. This spikes every other tie, and prevents the men running around each other.

1 man with a claw bar and adze to pull out the spikes that come in the way of the angle bars at the new joint, and to adze down the high ties at the new joint.

5 men putting on angle bars, and bolting up, putting two bolts at each joint, all bolts and angle bars to be distributed ahead of the rail laying for each day's work only. Have plenty of wrenches and spike mauls, and when connection is being made, or waiting for trains, turn the men that are working in the tong gang and those throwing out rail, back to do full bolting and full spiking.

2 men with a push car, to keep the connection rails, off-set splices, and everything needed in making a connection, and extra tools, right up with the rail-laying, so that when connection is to be made they will be on the ground. Have the spikers and bolters in starting out assist these two men in loading the connection rails. Always move the last new rail ahead and use it as a connection rail all the way through. This will always give you a good joint.

The foreman should watch the time of the regular trains, and go ahead of the spike pullers, and pick out

his place for making a connection, and have four picked men out of the gang that set in the rail to make the connection, using short pieces of rail. I used pieces from 4 ft. to 4 ins. long and used off-set bars from 90 lbs. to 80 lbs. I always found that my new rail fell short. I was putting down 33-ft. rail and taking up 30-ft. rail, and every ten rail lengths we could make a good connection by pulling the 80-lb. rail against the 90-lb. and using short pieces of 80-lb. rail to fill in the gap. In closing up at night, if I thought it necessary, I would cut in a long piece of rail.

The two men handling the push car and keeping the tools and connections up with the rail laying, should also keep the tools in good repair, such as keeping handles in the mauls, and have a general supervision of the tools.

The assistant foreman should be back among the workmen and see that the track is kept safe spiked and bolted, and ready for trains by the time a connection is made.

Section men should follow up and tamp any ties that may be hanging or shim them up as the season of the year may require.

Gage the track when you space the ties, as you will have to do it at that time any way, and it avoids cutting up the ties with spikes.

In taking up 80-lb. rail and putting down 90-lb. rail, pull the outside spikes of both rails. In doing this you avoid adzing, as the new rail will set up on the shoulder of the tie on the outside and give the wheels a full bearing on the ball of the rail. In taking up and laying rail of the same size, pull the inside spikes on both rails, and adze the ties down so as to give the wheel a perfect bearing on the ball of the rail. To do this it would take five extra men to do the adzing above the 44.

Pull bolt and spike the new rail and uncouple the old rail as far as you go each day. This usually can be done while waiting on trains. If not, take the time to do it. This is the reason I did not work larger gangs of men, as 44 or 46 men just about cleaned up each day's work even.

This rail laying was done on single track where we had an average of 17 trains in our 10 working hours, and was laid at a cost of $134.24 per mile. We laid an average of 3,500 ft. of rail per day.

After discussion, the report was adopted with one slight change, as embodying the best railway practice.

But one session was held on Wednesday, the first part of it being given to the election of officers for the ensuing year. Mr. James Sweeney, Danville, Ill., Supervisor of the Chicago & East Illinois Ry., the retiring 1st Vice-President, was elected President; T. Thompson, Joliet, Ill., Roadmaster of the Atchison, Topeka & Santa Fe Ry., 1st Vice-President; J. L. Single, of Newark, N. J., 2d Vice-President; and Mr. Walter E. Emery, of Peoria, Ill., Chief Engineeer of the Peoria & Pekin Union Ry., was re-elected Secretary and Treasurer. The following were elected members of the Executive Committee: A. E. Muschott, Joliet, Ill., Roadmaster of the Central Division of the Chicago, Rock Island & Pacific Ry., with term expiring in 1912; C. J. Muschott, Benton Harbor, Mich., Division Roadmaster of the Pere Marquette R. R., (1910); M. H. Connolly, Van Wert, Ohio, Supervisor of the Cincinnati Northern R. R. (1911); and F. D. Harrigan, Saginaw, Mich., Division Roadmaster of the Pere Marquette R. R., (1913). After election of officers, the convention fixed upon Chicago, Ill., as their next place of meeting, and the date November 8, 1910. The rest of the morning session was given up to a consideration of the report of the Committee on comparative values of crushed stone, furnace slag, chats, gravel or burnt gumbo as ballast, under heavy traffic, submitted by the Chairman, P. J. McAndrews, Roadmaster of the Chicago & Northwestern Ry.

Thursday's session was given up to the discussion and adoption of reports on different kinds of rail fastenings, including insulated joints, Chairman of Committee, J. E. McNeil, Inspector of Track and Roadway on the Santa Fe Ry., with headquarters at Los Angeles, Cal., and on varieties of tie plates and their virtues, by the Committee of which President James Sweeney was Chairman.

On Friday, at the last session, a report was read, signed by L. Lawler, of Lake Charles, La., Roadmaster of the Louisiana Western R. R., on new and improved appliances. This was adopted without discussion, and after an address of farewell on behalf of the supply men, by Mr. W. C. Kidd, representing the Ramapo Iron Works, the convention adjourned at ten o'clock.

During the convention the usual sightseeing trips about Washington were made, and after adjournment upon invitation of Mr. S. B. Rice, General Roadmaster of the Richmond, Fredericksburg & Potomac Ry., a number of the members took a special train for Richmond to look at the new gravel washer recently installed by that railway and illustrated in Engineering News of April 15, 1909.

Gas Engines for Boosting Gas Pressure in Service Lines.*

An installation of gas engines for boosting the pressure in illuminating-gas pipe lines, has recently been contracted for by the Public Service Corporation of New Jersey. At its Hoboken and Passaic plants four vertical, 13 × 12-in. gas engines, equipped with a special regulating mechanism, will be employed to drive direct-connected Root type blowers delivering gas at pressures varying from 0.75 to 4 lbs. per sq. in., as desired.

The delivery of gas by the blowers is automatically made to conform to the demand on the gas lines, by increasing the speed of the engines as the pressure in the mains tends to fall. To accomplish this, a special controlling valve has been added which throttles the fuel admitted to the engine, adjusting the speed between 290 and 125 r.p.m., as the demand for gas varies. The controlling valve is operated by a piston, which is moved by the pressure in the gas reservoir line against the compression of a helical spring, to close the fuel valve as the line pressure rises. This controlling valve is fitted with a positive stop so adjusted that, even though the line pressure reaches its full value, the fuel valve cannot close beyond a point where the engine will continue to turn over on light load. This avoids the necessity of restarting the engine when the blower pressure is again required. While it is estimated that the minimum demand on the pipe lines will probably absorb the delivery of the blower at its lowest speed (125 r.p.m.), any possible abnormal rise in pressure is prevented by the provision of relief valves which automatically open a by-pass around the blower, enabling the engine to run light while performing no other work than circulating the gas in a local circuit. A standard governor device has also been supplied with these engines, but adjusted with considerable play or backlash, so that the governor does not control the gas admission until the engine speed exceeds 250 revolutions per minute. Above this, the governor travel takes up the backlash and throttles the gas to preventing any possibility of overspeeding, in case the pressure in the transmission line should suddenly be relieved.

The location of the boosting equipment dictated the use of a magneto generator, for ignition current, driven from the main engines. The feature of obtaining approximately constant speed for the ignition-current generator run from an engine of widely varying speed, is unique. A magneto is used, which is designed to have its armature run at 2,000 to 2,500 r.p.m. It is driven by friction contact with the side face of the fly-wheel rim, which, it was stated, varied in speed from 125 to 290 r.p.m. A governor pulley is attached to the armature, so acting that the pulley is momentarily withdrawn from contact with the fly-wheel rim. Therefore when the fly-wheel is running at the higher speeds the magneto pulley receives only impulses enough to keep it at approximately normal constant speed.

The gas engines are each of 90-B.H.P. capacity, and use illuminating gas from the supply lines, with a heat value of approximately 600 B.T.U. per cu. ft. The engines are direct-connected to the blowers through flexible rope couplings. A single-phase alternating-current motor drives a 3 × 4-in. belted air compressor to supply storage tanks for starting the engines. The gas engines were manufactured by the Westinghouse Machine Co. of Pittsburg.

*Arranged from information supplied by the Westinghouse Machine Co., Pittsburg.

A BUILDING COLLAPSED during construction at Chicago, Ill., Sept. 17. Three men were killed and twelve others were injured. The building was a three-story brick structure.

A SAWMILL BOILER EXPLODED at Middlepark, Jackson Co., W. Va., Sept. 16. Two men were killed outright and a third was fatally injured.

THE STEAMSHIP "NICHOLAS CASTANIA" went ashore on the south coast of the Isle of Pines, near Cuba on the night of Aug. 23. Just as the steamer was thrown on the rocks by the waves, her boilers exploded, wrecking the hull and superstructure. All of the 29 persons on board are believed to have perished, although only 18 bodies, badly mangled by the explosion, were found.

A STEAM PIPE BURST on board the U. S. cruiser "Colorado" Sept. 8 and two men were killed by the escaping steam. The "Colorado" was one of the eight vessels of the Pacific fleet which left San Francisco Sept. 5 for Honolulu. The flagship "Tennessee" made the trip in 4 days and 17 hours and the accident on the "Colorado" occurred while she was steaming under forced draft in an effort to maintain the pace set by the flagship.

AN EXPLOSION OF DYNAMITE, which was accidentally ignited by a miner's candle in the Eureka mine near Bessemer, Mich., Sept. 17, caused the death of two men and the injury of two others.

An explosion in a fireworks factory at Riace, Calabria, Italy, Sept. 17, killed twelve persons and wrecked the factory.

The explosion of a powder magazine at Iligh, near Mogador, Morocco, Sept. 16, is reported to have killed 200 persons. The magazine was near the market place and the explosion occurred at noon when the market place was crowded.

A LOCOMOTIVE STRUCK A FIRE ENGINE in Elizabeth, N. J., Sept. 16, on a grade crossing of the Central R. R. of New Jersey. The driver was probably fatally injured and the horses were killed. The fire engine was responding to an alarm and was approaching the crossing, which is provided with gates, at full speed. The flagman at the crossing decided to give the right-of-way to the fire engine and, instead of lowering the gates he stepped out on the track and signaled with a lantern for the approaching train to stop. The engineer afterward claimed that he did not see the signal.

A HURRICANE SWEPT THE GULF STATES Sept. 20, doing an immense amount of damage in Louisiana, Mississippi and Alabama. The wind velocity at New Orleans is reported to have attained 78 mi. per hr., and 90 mi. per hr. in southern Mississippi, where the storm was most violent. In addition to the damage to buildings, a large amount of standing timber was felled by the wind.

A FREIGHT AND A PASSENGER TRAIN COLLIDED head-on Sept. 15 on the Nashville, Chattanooga & St. Louis Ry., one mile west of Pegram station, Tennessee. Eight trainmen were killed, and a fire starting in the wreckage consumed six of the bodies. The wreck is ascribed to the overlooking of orders.

A PECULIAR FLYWHEEL ACCIDENT occurred at Mineola, Long Island, Sept. 20. An iron bucket, used for raising stone from a crusher to the workers on a concrete bridge, fell and struck the flywheel of the stone crusher. The flywheel burst and the engineer of the crusher was killed by one of its flying fragments.

THE MANHATTAN BRIDGE, the latest suspension bridge now under construction across the East River at New York City, has been approved in design and construction by Mr. Ralph Modjeski, who was called in by the city about a year ago, after certain charges against the safety of the bridge had been filed by the City Club. Mr. Modjeski's report is not yet available in its entirety, but its general tone is favorable to the bridge. With the exception of the Manhattan anchorage, which he says could have been strengthened by driving inclined piles in the foundation, the design is in accordance with best practice and the construction fully up to the standard.

It is now reported that the bridge will be open for traffic by December of the present year, but the transit arrangements are still in an unformed state and are likely to be so for some time.

THE MULBERRY ST. VIADUCT, HARRISBURG, PA., one of the largest concrete bridges in the world, was opened for traffic Sept. 6, 1909. This viaduct, which replaces an old steel bridge injured by fire several years ago, consists of a series of 24 reinforced-concrete arches,

varying in span from 40 to 100 ft. The main bridge, with a 28-ft. roadway and two 8-ft. sidewalks, is 1,800 ft. long, and there is a 600-ft. inclined approach with a 24-ft. roadway and one 6-ft. sidewalk. There is in it about 20,600 cu. yds. of concrete and 600 tons of steel, and it cost about $262,000.

A PROFESSOR OF ENGINEERING is to be appointed in the University of Melbourne, Australia, and applications from candidates for the vacancy are being advertised for simultaneously in Australia, Great Britain and the United States. The salary is £1,000 per annum, of which £100 per annum is deducted and applied to annual payments on an endowment life-insurance policy payable at the age of 60, or at death should that occur at an earlier age. The academic year begins during the first week in March and ends before Christmas, and contains approximately 30 weeks of lectures and laboratory work. Applications for the vacancy from candidates resident in America, together with original or certified copies of testimonials or photographs, must be sent to the British Consul, 17 State St., New York, City, to reach him by Oct. 15, 1909. Circulars giving complete information may be obtained by addressing the Consul. The professional qualifications of the candidate are dealt with as follows, in the circular:

The Professor must be specially qualified to teach the mechanical principles which are usually included in Applied Statics and Dynamics, Applied Thermo-dynamics, Theory of Mechanism, Principles of Design and Construction together with the properties of the materials which are the subject matter of Engineering.

He should be a man of real engineering bent, talent and originality; capable of teaching from the engineering standpoint the scientific principles of engineering. He should not be merely a mathematician or a physicist or a laboratory professor of engineering, but a man who by energy, training and experience as an engineer, can teach the students how to make good use of scientific principles in engineering work. It should be his special duty to teach those subjects which are of equal fundamental importance to all branches of engineering, and which can be most satisfactorily dealt with by a man whose whole time can be devoted to the consideration and teaching of engineering principles.

A HEIGHT RECORD for aeroplane flyers was established by Orville Wright at Berlin, Germany, on Sept. 17. He reached an altitude of approximately 182 meters (600 ft.), according to army officers, but estimated himself his height at 212 meters (700 ft.).

MODELS OF THE "CLERMONT" and other early steamboats are now on exhibition at the rooms of the American Society of Mechanical Engineers, 29 West 39th St., New York City. The exhibit includes the "Clermont"; the "Phoenix," built by John Stevens; and one of John Fitch's first steamboats, propelled by oars instead of paddle wheels. In addition, there are exhibited some original drawings by Robert Fulton, an oil portrait of Fulton painted by himself, Fulton's dining table, oil portraits and a bronze bust of John Ericson, models of the "Monitor" and Ericson's personal exhibit at the Centennial Exposition. A model of the Hamburg-American liner "Deutschland" shows the present stage of the development of steam navigation.

The model of the "Clermont" represents the vessel as she was on her maiden trip. The dimensions of the model were taken from a letter written by Fulton to James Watt, in which her length is given as 175 ft., beam 12 ft., and depth 8 ft. After her fourth trip, her length was reduced to 150 ft. and her width increased to 18 ft. The "Clermont" as built for the Hudson-Fulton celebration this fall has the latter dimensions. The engine of the model differs from that of the new "Clermont" in having but one flywheel, placed on the same shaft between the paddle wheels. The newer vessel has a flywheel outside the hull on each side. Four men were required to start the engine of the first "Clermont" on account of the imperfection of the valve gear which was afterward changed to the Stevens type.

The "Phoenix," 103 ft. 3 ins. long, 16 ft. wide and 6 ft. 9 ins. deep, made the first sea voyage accomplished by a steam-propelled vessel in June, 1809, when she sailed from New York City to Philadelphia. The model of John Fitch's boat represents a vessel 34 ft. long, 8 ft. wide and 3 ft. 6 ins. deep. It was equipped with a steam engine which drove, through a chain-and-sprocket gear, two sets of six oars each placed vertically in frames, one set on each side of the boat. A successful public trial of this boat was made in Philadelphia in 1786. The exhibit will be open to the public every week day from 9 a. m. to 5 p. m.

Personals.

Mr. W. E. Ballantine, Chief Electrician of the Chicago, Rock Island & Pacific Ry., with headquarters at Chicago, Ill., has resigned and will be succeeded by Mr. F. E. Hutchinson.

Mr. Robert I. Todd, Vice-President of the Terre Haute, Indianapolis & Eastern Traction Co., has become General Manager, succeeding Mr. C. C. Reynolds, deceased. Mr. Todd is also Vice-President & General Manager of the Indianapolis Traction & Terminal Co.

Mr. Morgan Brooks, M. Am. Inst. E. E., Professor of electrical engineering at the University of Illinois, is to be absent on leave during the present school year. He will sail from San Francisco Oct. 12 on a trip which ultimately will take him around the world.

Mr. H. J. Saunders, for several years Assistant Engineer in charge of shop building, bridge and construction work for the Union Pacific R. R., has entered the employ of the Arnold Co., of Chicago, Ill., and is now in charge of irrigation construction work near Laramie, Wyo.

Mr. R. S. Moore, recently with the Detroit River Tunnel Co., has entered the employ of Waddell & Harrington, Consulting Engineers, Kansas City, Mo. Mr. Moore is a graduate of the Pennsylvania State College, class of 1897, and was employed for a number of years in the bridge department of the Illinois Central R. R. During the construction of the Pennsylvania R. R. tunnels at New York City, he was an assistant engineer on the East River division.

Col. Daniel W. Lockwood, Corps of Engineers, U. S. Army, was retired for age Sept. 21. Col. Lockwood was graduated at West Point in the class of 1866 and attained the rank of colonel in September, 1906. During the past year he has been Division Engineer of the eastern division with headquarters at New York City, and has had charge of the construction of bridges and of waterway improvements in eastern New Jersey. Col. Lockwood will be relieved of his duties at New York City by Col. Wm. T. Rossell, Corps of Engineers, Division Engineers of the central division at Cincinnati, Ohio. Lieut.-Col. James G. Warren, Corps of Engineers, will succeed Col. Rossell as Division Engineer of the central division.

Obituary.

Joseph F. Murphy, General Foreman of the Houston & Texas Central R. R., died last week at his home in Ennis, Tex.

Jason Wallace, who resigned four years ago as Superintendent of Buildings and Bridges of the Chicago, Burlington & Quincy R. R., died Sept. 11 at Aurora, Ill., aged 82 years.

Turlington W. Harvey, President of the Harvey Steel Car Co., and founder of the town of Harvey, Ill., died at Littleton, N. H., Sept. 12. Mr. Harvey was born in Madison Co., N. Y., in 1835.

Charles K. Moore, a civil engineer living in New York City, committed suicide Sept. 16. Mr. Moore was 51 years old and is claimed to be a great-grandnephew of Robert Fulton. Two years ago, while working in the East River tunnel of the Pennsylvania R. R. he suffered an attack of the "bends" which incapacitated him for further work.

James Henry Covode, M. Am. Soc. C. E., died Sept. 9 in Bolivia, South America, where he was engaged in special work for a New York mining syndicate. Mr. Covode was born in 1864 and was a graduate of the Rensselaer Polytechnic Institute in the class of 1882. He took part in the survey for the Nicaragua Canal in 1884 and was afterward employed for a number of years by the Pennsylvania R. R. Since 1897 his time has been largely devoted to mining engineering.

Robert A. Crawford, U. S. Assistant Engineer, died Aug. 19, at Los Angeles, Cal., at the age of 44 years. Mr. Crawford was born in Athens, Ga., and graduated with honors at the University of Georgia in the class of 1884. Soon after graduation, he entered the Government service in connection with the work of improving the Missouri River, and while there conducted extensive surveys and also had charge of a number of construction parties engaged in regularization work. He also had charge in 1900-1 of some of the large hydraulic dredges on the lower Mississippi River. In 1901 he left the Government service temporarily to assist in the work of constructing the St. Louis Exposition, after which he returned to the Government service and designed and built the hydraulic dredge "San Pedro," of which he has had charge since 1903 at San Pedro inner harbor, Cal. Mr. Crawford was conscientious and devoted to his work almost to a fault, and although in failing health for a number of years his devotion to duty never flagged and he remained in active charge of his station until within a few hours of his death.

Joseph Nelson Tubbs, M. Am. Soc. C. E., died Sept. 20 at his home in Rochester, N. Y. Mr. Tubbs was born in Schoharie Co., N. Y., in 1832 and was educated at the academy at Esperance, N. Y., and in the State Normal School at Albany, N. Y. After teaching school for four years, he obtained a position, in 1854, on the work of enlarging the Erie Canal. He remained in the New York State service for 18 years, resigning in 1872 to become Chief Engineer of the Rochester water-works. He resigned this position in 1892 in order to devote his entire time to his practice as a consulting engineer. During most of the time that he was Chief Engineer of the Rochester water-works, he was also Chief Engineer and Superintendent of the Elmira reformatory.

As a consulting engineer, he was in charge of the construction of water-works in various parts of New York State, including the Syracuse water-works, which, during construction, he was Chief Consulting Engineer. Early in 1894 he was appointed General Inspector of the public works of all canals in New York, a position which he held for ten years. Mr. Tubbs was a member of the American Water Works Association and of the New England Water Works Association.

Engineering Societies.

COMING MEETINGS.

ILLUMINATING ENGINEERING SOCIETY.
Sept. 27-29. Annual convention at New York City. Secy., P. S. Millar, 25 W. 39th St., New York City.

AMERICAN MINING CONGRESS.
Sept. 27-Oct. 2. Annual session at Goldfield, Nev. Secy., J. F. Callbreath, Jr., Denver, Colo.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.
Oct. 4-8. Annual convention at Denver, Colo. Secy., Bernard V. Swenson, 29 W. 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 12-14. Annual convention at Louisville, Ky. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 19. Annual convention at Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine R. R., Concord, N. H.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 19-22. Annual convention at Richmond, Va. Secy., Chas. O. Probst, Columbus, Ohio.

AMERICAN GAS INSTITUTE.
Oct. 20. Annual meeting at Detroit, Mich. Secy., A. B. Beadle, 29 W. 39th St., New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 29-30. Annual meeting at New York City. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Nov. 9-11. Annual convention at Little Rock, Ark. Secy., A. P. Folwell, 239 West 39th St., New York City.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 16. Annual meeting at Washington, D. C. Secy., Martin S. Decker, Albany, N. Y.

AMERICAN RAILWAY ASSOCIATION.
Nov. 17. Annual meeting at Chicago, Ill. Secy., W. F. Allen, 24 Park Place, N. Y.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—At the meeting in New York City Sept. 22, Mr. J. C. Meem presented a paper entitled "Construction Problems of the Brooklyn Subway."

NEW YORK RAILROAD CLUB.—At the regular meeting of Sept. 17, Mr. Frederick C. Syze, Trainmaster of the Baltimore & Ohio R. R., presented a paper on "Surprise and Efficiency Tests of Employees Charged with the Operation of Trains."

WESTERN RAILWAY CLUB.—At the regular monthly meeting in Chicago, Ill., Sept. 21, Mr. Geo. S. Payson gave an address on "The Relations of the Western Railroad Association to Railways and the Manufacturers of Railway Devices," which was particularly directed to those who have to do with the sale of patented devices to railways.

WESTERN SOCIETY OF ENGINEERS.—At a largely attended meeting held in the Society's rooms at Chicago on Sept. 15, a paper on "The Chicago Harbor" was read by Mr. John M. Ewen, who was chairman of the special harbor commission appointed by the Mayor. The extended report made by that committee was reviewed in our issue of April 29. Mr. Ewen pointed out that while the movement of freight on the Great Lakes has increased tremendously during the past decade, the Chicago River Harbor is the only lake harbor which shows a large decline. The suggestions for harbor development included the establishment of docks and other facilities on the lake front, the widening and straightening of the river, and the eventual establishment of a harbor on Lake Calumet. This last would be of the same general design as the proposed Newark Harbor, consisting of a broad channel with rectangular docks opening from both sides.

In the course of a rather desultory discussion, Mr. G. A. M. Liljencranz, Assistant U. S. Engineer, described the work which has been done by the Federal Government in improving the river. Mr. J. C. Bley, of the city's engineering department, took exception to the proposal to require bridges of 200-ft. span where the channel is of this width. Vessels have the right to tie up at the sides of the river, so that projecting abutments and a 140-ft. span (as at present) are admissible. Mr. Ewen explained that these projecting abutments reduce the channel capacity and hinder navigation, besides causing currents and eddies which make it difficult to control vessels passing through the narrowed channel. One speaker suggested an outer harbor extending from Evanston to the Calumet River, about 24 miles long and with a width of two miles. This would be formed by a great breakwater parallel with the shore, and he considered that this could be built at comparatively small cost by using the waste rock now lying in piles along the drainage canal.